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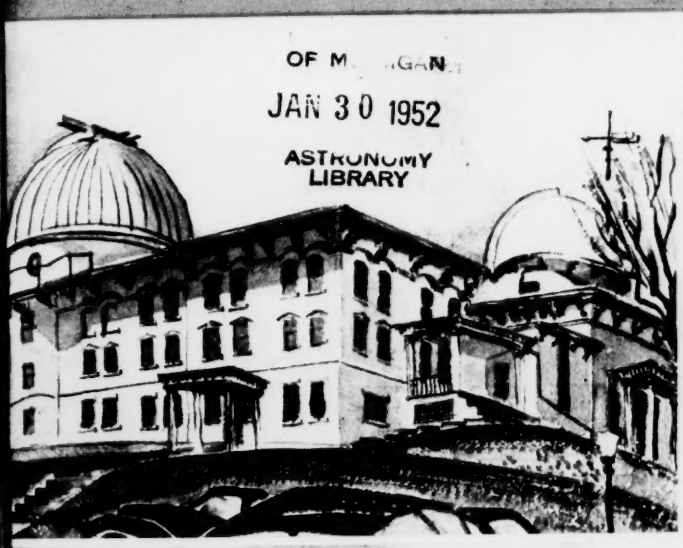

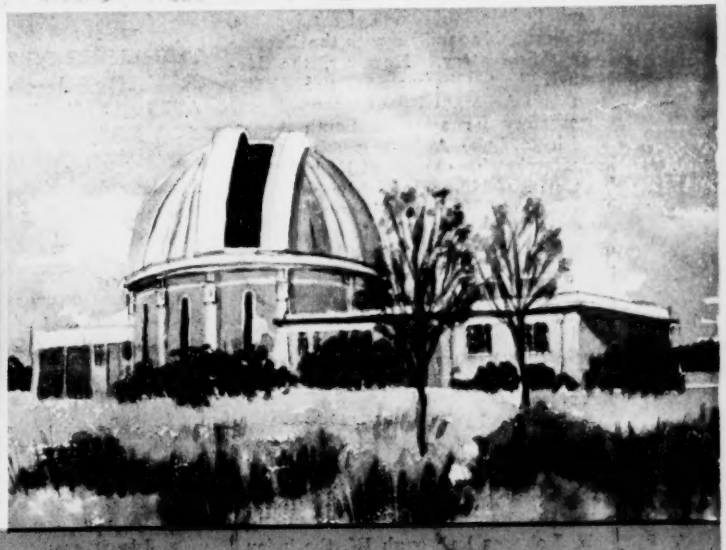

Michigan water colors

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Vol. XI, No. 4
FEBRUARY, 1952
Whole Number 124

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In This Issue:

Jupiter XII

Astronautics Looks Ahead

The Hottest Star — II

American Astronomers Report

Northern and Southern Star Charts

In Focus

WHEN the question arose of choosing a suitable gift for Dr. and Mrs. Leo Goldberg, to mark the fifth anniversary of the former's appointment as director of the observatories of the University of Michigan, it was decided that a set of water colors of the four observatories would be especially appropriate, and Herbert W. Johe agreed to execute them. His results are shown in miniature on the cover of this magazine.

Mr. Johe is assistant professor of architecture in the University of Michigan. As a student at the Carnegie Institute of Technology, his training included the study of water color, at that time considered an indispensable architectural skill. In later years, painting has been primarily his hobby; his work includes a wide variety of subjects, with emphasis on buildings of special architectural interest. His paintings have been hung in exhibits as widely separated as Michigan and the Honolulu Art Academy.

In 1950, Mrs. Miller, who had greatly admired a number of water colors done by Mr. Johe during two years in the Hawaiian Islands, commissioned a painting of the Portage Lake Observatory as a Christmas gift for the undersigned. The artist's interest in experimentation with various water-color techniques led to a series of three renderings of the same view in wet-paper, dry-brush, and impressionistic styles, respectively. The first of these was finally selected and now hangs at the observatory.

For the four new paintings, the observatory in Ann Arbor, on the edge of the university campus, was readily accessible and presented no difficulties. The painting was done on the spot, under the supervision of numerous passers-by on their way to or from the adjacent University Hospital. Mr. Johe was, by this time, also thoroughly familiar with the Portage Lake Observatory. However, the McMath-Hulbert Observatory is 50 miles from Ann Arbor, and the Lamont-Hussey Observatory far away in South Africa. A visit to Lake Angelus yielded a preliminary sketch and a set of Kodachromes from which the final view was painted. The Lamont-Hussey Observatory was executed from a set of Kodachrome slides taken by Karl G. Henize while he was at that station a short while ago.

The McMath-Hulbert painting was presented to the Goldbergs by Dr. Robert R. McMath as a personal gift, and the three remaining water colors were a gift of the staff members and students of Michigan's observatories.

FREEMAN D. MILLER
University of Michigan Observatory

INDEXES AND BACK ISSUES

of **Sky and Telescope** are available. For Volumes I through IX, the index is 35 cents postpaid; it is included without charge in the October, 1951, issue for Volume X. For back issues, let us know your needs and we shall try to fill them.

SKY PUBLISHING CORPORATION

Sky and TELESCOPE

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The University of Michigan Observatories

ANN ARBOR. The original building, completed in 1854, contains a meridian circle, and a Fitz 12-inch refractor erected in 1857. Present-day research is carried out only with the 37½-inch Cassegrainian reflector, which since 1911 has had a distinguished career of spectroscopic research, first under R. H. Curtiss, and during the past 22 years in the hands of D. B. McLaughlin. The telescope is equipped with interchangeable prism spectrographs, and is used chiefly for *Be* stars, composite stars, novae, and other peculiar objects. L. H. Aller is paying particular attention to stars that show sporadic, rapid variations in the intensities of their emission lines, especially T Tauri, BF Cygni, and other similar stars. In addition to his long-standing work on novae spectra, Dr. McLaughlin has been studying 31 Cygni.

The Ann Arbor observatory serves as the general headquarters of the university's department of astronomy, and it has a large instrument shop. Eighteen graduate students are in residence.

PORTAGE LAKE. The main building houses a 24-36-inch Schmidt reflector by Warner and Swasey, with optics by Perkin-Elmer. Two full-aperture objective prisms, of four and six degrees, respectively, may be used singly or in conjunction to give any desired prism angle between two and 10 degrees. A Newtonian flat makes possible observation with a photoelectric photometer and amplifier constructed by William Liller; at present, however, the photometer is being used with the 24-inch reflector at Lake Angelus. Also at

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FEBRUARY, 1952

COVER: Photographs of water colors of the four University of Michigan research observatories, painted by Herbert W. Johe. At top left is the Ann Arbor headquarters; top right, Portage Lake, Mich.; bottom left, McMath-Hulbert at Lake Angelus, Mich.; bottom right, Lamont-Hussey in South Africa. University of Michigan photographs. (See the article on this page and In Focus.)

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BACK COVER: A planetary nebula in Hydra, NGC 3242, at $10^h\ 22^m.4$, $-18°\ 23'.2$ (1950 co-ordinates), one of the five most easily observed planetaries, according to L. S. Copeland. Its central star is of magnitude 11.3 visual, but 9th magnitude photographic. The outer ring has an apparent size of 40 by 35 seconds of arc. This photograph was taken in red light with the 200-inch Hale telescope. Mount Wilson and Palomar Observatories photograph. (See page 86.)

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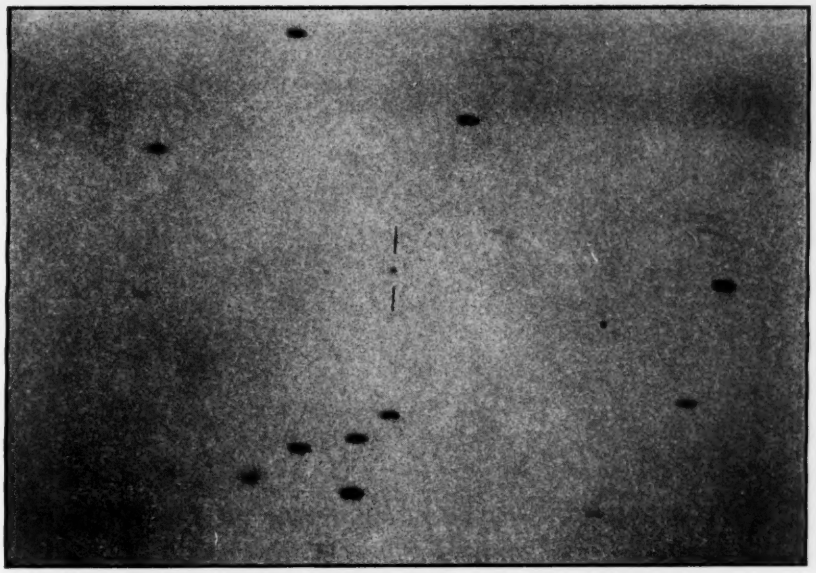
JUPITER XII

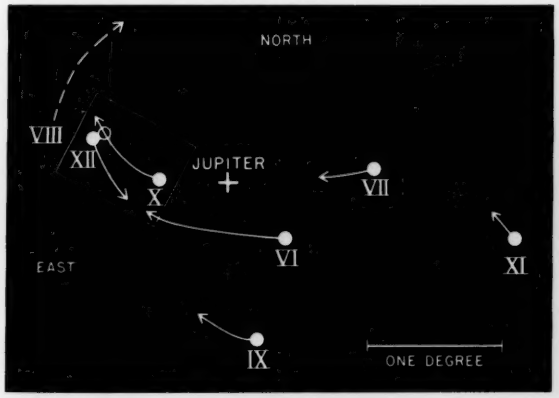
By Seth B. Nicholson
Mount Wilson and Palomar Observatories

THE 12th satellite of Jupiter was discovered on September 29, 1951, in the same way that the eighth and ninth satellites were discovered — by accident. J VIII was found by P. J. Melotte in 1908 on a photograph of J VI and J VII taken at Greenwich, England, and J IX by the writer in 1914, at the Lick Observatory on a photograph of J VIII. The new satellite was discovered on a photograph of J X taken on Mount Wilson. In fact, J XII was so much closer to the predicted position of J X than J X itself was, that I at first misidentified these satellites. The diagram shows the positions of Jupiter's outer satellites on September 29th. The field covered by the discovery plate is indicated by a rectangle and the predicted place of J X by an open circle.

The 100-inch telescope had been assigned to me on the nights of September 27th and 28th for the purpose of determining the positions of the faint satellites of Jupiter. An ephemeris of J IX had been published by Dr. Samuel Herrick, of the University of California at Los Angeles, and approximate ephemerides of J X and J XI had, upon request, been sent to me from Cincinnati Observatory by Dr. P. Musen. The night of September 27-28 was partly cloudy, with poor seeing, and after I had photographed J XI, clouds prevented further observing that night. On the next night the atmospheric conditions were much better, and duplicate photographs of IX, X, and XI were obtained; at least, images of objects moving along with Jupiter were found near the positions predicted for each



Part of the discovery plate of Jupiter XII (centered). The height of this picture is equal to the diameter of the circle marking the position of the new satellite on the diagram below. On this scale, enlarged four times from the original negative, Jupiter was about 38 inches to the right (west), and Jupiter X (at first thought to be Jupiter XII) was about 20 inches to the right. The sides of this picture are parallel to those of the rectangle in the diagram. Because the plate was oriented parallel to the ecliptic, the star trails appear horizontal here. The exposure was 30 minutes, and the motion in that time (primarily that of Jupiter) was eight seconds of arc. The 100-inch Hooker telescope pictured below took this Mount Wilson and Palomar Observatories photograph.



The cause of the confusion on the discovery plate of Jupiter XII. The chart above gives the positions of Jupiter's distant satellites on September 29, 1951. The arrows show their motions relative to Jupiter during October. The place where J X had been predicted for September 29th is marked by an open circle; actually it did not reach that place until about 20 days later. The rectangle indicates the relative size and position of the discovery plate, a portion of which is reproduced above. The path of J VIII is only approximate; this satellite was not observed. On November 5th, J VI and J XII passed within one minute of arc of each other. Mount Wilson and Palomar Observatories diagram.

HARVARD COLLEGE OBSERVATORY

ANNOUNCEMENT CARD 1147

1951 October 8

New Satellite of Jupiter. — A telegram from Dr. Ira S. Bowen, Mount Wilson and Palomar Observatories, reports the discovery of a nineteenth magnitude object, probably a new satellite of Jupiter, photographed in the following positions with reference to the position of Jupiter:

1951 U.T.	R.A.	Dec.
	m	′
Sept. 29.25	+2	+0.4
Oct. 4.40	+2.5	+7.1

The above observations were made on plates taken with the 100-inch telescope by Dr. Seth B. Nicholson and were confirmed on photographs by Dr. L. E. Cunningham with the 60-inch.

ANNOUNCEMENT CARD 1152

1951 October 25

Jupiter XII. — Dr. E. Rabe, of the Cincinnati Observatory, reported on October 16: "Computations by Dr. P. Musen of the Cincinnati Observatory prove that the object in HAC 1147 is the tenth satellite of Jupiter."

The distribution of this statement was temporarily withheld upon the telephonic advice of Dr. Rabe on October 17. The uncertainty in the identification is discussed by Dr. Cunningham on HAC 1153.

Dr. Leland E. Cunningham, Leuschner Observatory, University of California, Berkeley, writes: "The photographs I secured (HAC 1147) of Nicholson's new satellite have been measured and reduced by Dr. A. G. Mowbray and Mrs. Alice Howard, as follows:

1951 U.T.	R.A. (1951.0)			Dec.		
	h	m	s	°	′	″
Sept. 30.29101	0	39	44.59	+2	18	08.0
30.30663	0	39	44.16	+2	18	06.8
Oct. 1.31775	0	39	19.29	+2	16	13.4
2.22609	0	38	56.82	+2	14	31.2
2.24814	0	38	56.23	+2	14	29.3
2.26428	0	38	55.85	+2	14	27.0

ANNOUNCEMENT CARD 1153

1951 October 25

Jupiter's New (?) Satellite. — Dr. Leland E. Cunningham, Leuschner Observatory, University of California, Berkeley, writes: "The general solution for the orbit of the object announced in HAC 1147 is essentially indeterminate by any method on the basis of positions 1951 September 29.2 to October 4.3; the deviation from great circle motion is only 3″. The planetary solution exists mathematically at r = 2.7; the range of solution about this value is very large, but all resulting orbits have high eccentricities, and the possibility that this object is a minor planet appears to be excluded. The two satellite solutions exist mathematically at 0.06 a.u. from Jupiter, one nearer and the other farther than that body; the ranges of solution are again very large, but include orbits of low eccentricity in each case. The orbits of the nearer solution are retrograde, and the minimum eccentricity is near 0.3. The orbits of the farther solution are direct, and the minimum eccentricity is near 0.15. The angular elements of an orbit chosen near the minimum eccentricity for the farther solution are

ω	305°
Ω	65
i	28

The inclination should be quite near the truth, the node could easily be changed by several degrees, and the longitude of perihelion is very uncertain. The similarity of these elements and those for Jupiter X is sufficiently marked, in view of the uncertainties involved, to lead to the suspicion that the supposed new satellite is actually X. Further observations are needed to settle the question conclusively.

ANNOUNCEMENT CARD 1154

1951 October 30

Jupiter's Satellites. — Dr. Seth B. Nicholson, of the Mount Wilson and Palomar Observatories, reports that he verifies the identification (HAC 1152) with JX of the object which was reported on HAC 1147 and for which positions were given on HAC 1151. Measures of an object, which on September 29 was near an ephemeris place of JX supplied by the Cincinnati Observatory, indicate that it is not JX, as first supposed. An observation of this second object on October 24 shows that it is moving as a satellite might. Objects of the right magnitudes were photographed on September 29 near the predicted places of JIX and JXI. The new object is fainter than JVIII, which is the only known satellite for which no new positions are available.

ANNOUNCEMENT CARD 1155

1951 November 8

Jupiter's Satellites. — The following position of the object near Jupiter reported on H.A.C. 1154 was obtained with the 100-inch telescope by Dr. Seth B. Nicholson, who states the object is almost certainly a new satellite.

1951 U.T.	R.A. (1950.0)			Dec.		
	h	m	s	°	′	″
Nov. 2.34722	0	25	44.66	+0	35	42.0

A much brighter object, probably J VIII, was 7′ due south at:

1951 U.T.	R.A. (1950.0)			Dec.		
	h	m	s	°	′	″
Nov. 2.34722	0	25	46.02	+0	28	53.9

Relative to Jupiter, this object was moving about 6′ west and 2′ north per day.

J VI was 8′ away, very close to its position as given in the American Ephemeris.

Minor planet (1003) Lilofee, magnitude 13, was also nearby at:

1951 U.T.	R.A. (1950.0)			Dec.		
	h	m	s	°	′	″
Nov. 2.34722	0	25	50.71	+0	26	59.0

ANNOUNCEMENT CARD 1156

1951 November 14

Jupiter XII. — Dr. Samuel Herrick, of the University of California at Los Angeles, reports as follows: Jupiter XII (HAC 1155) ellipse:

ELEMENTS

1951 Oct.	24.353 U.T.
M	260° 50′
ω	316 22
Ω	227 47
i	147 17
φ	7 59
μ	2076″.9

Three-body Gibbsian solution by Joseph Brady and Charles Hilton. Great circle departure is small. Other solutions are nearly parabolic.

ANNOUNCEMENT CARD 1160 1161

1951 November 21

Jupiter XII.[1] — Dr. Leland E. Cunningham, Leuschner Observatory, University of California, Berkeley, writes: "The following positions of Nicholson's new satellite (HAC 1154) have been measured by Dr. Albert G. Mowbray on plates I secured with the 60″ reflector on Mount Wilson.

1951 U.T.	R.A.		(1951.0)		Dec.	
	h	m	s	°	′	″
Oct. 2.42192	0	40	32.75	+2	24	36.1
2.43824	0	40	32.27	+2	24	32.6

A roundabout comparison with the North Polar Sequence gave magnitude 18.3, provisionally, for the brightness of the satellite on the above date.

The general solution for the orbit of this satellite is moderately well determined, with a deviation from great-circle motion of 40″. The planetary solution at r = 3.7 leads to a hyperbolic orbit; the nearer satellite solution at 0.16 a.u. from Jupiter leads to an orbit with eccentricity of 0.8; the farther satellite solution leads to an orbit of low eccentricity and semi-major axis quite close to the quantized value for the outer group of satellites, and establishes conclusively the nature of this object. A *direct solution* led at once to the elements, residuals and ephemeris below; solar perturbations were included throughout.

ELEMENTS, 1950.0

Osculation 1951 Oct. 24.32946 U.T.
T 1952 Apr. 15.86905 U.T.

	°			
ω	318.527		a	0.139615
Ω	228.047	1950.0	e	0.134560
i	147.346		°	
			μ°	0.583793

EPHEMERIS, 1951.0

1951 U.T.	R.A.		Dec.		ρ	r_{Jup}	r_{Sun}	Mag.
	h	m	°	′				
Oct. 31.0	0	26.72	+0	42.7	4.204	0.145	5.086	18.5
Nov. 10.0	0	23.18	+0	17.5	4.300	0.143	5.085	18.6
20.0	0	20.71	+0	00.3	4.416	0.141	5.083	18.7
30.0	0	19.44	−0	08.2	4.549	0.139	5.079	18.8
Dec. 10.0	0	19.41	−0	07.8	4.694	0.138	5.074	18.9
20.0	0	20.63	+0	01.2	4.845	0.136	5.067	19.0
30.0	0	23.02	+0	18.4	4.998	0.135	5.059	19.1

HARLOW SHAPLEY

These extracts from Harvard Announcement Cards tell the story of Jupiter XII from the viewpoint of the professional astronomer, and reveal the problems often confronting observers and computers in establishing the identities of such faint objects. The more technical portions of some cards have been omitted.

of those satellites. When these exposures had been completed, there remained enough observing time for two photographs of an additional field. The region between the ephemeris position of J X and Jupiter was chosen for these photographs and the settings were made so that they would overlap with the field of J X, covered earlier that night.

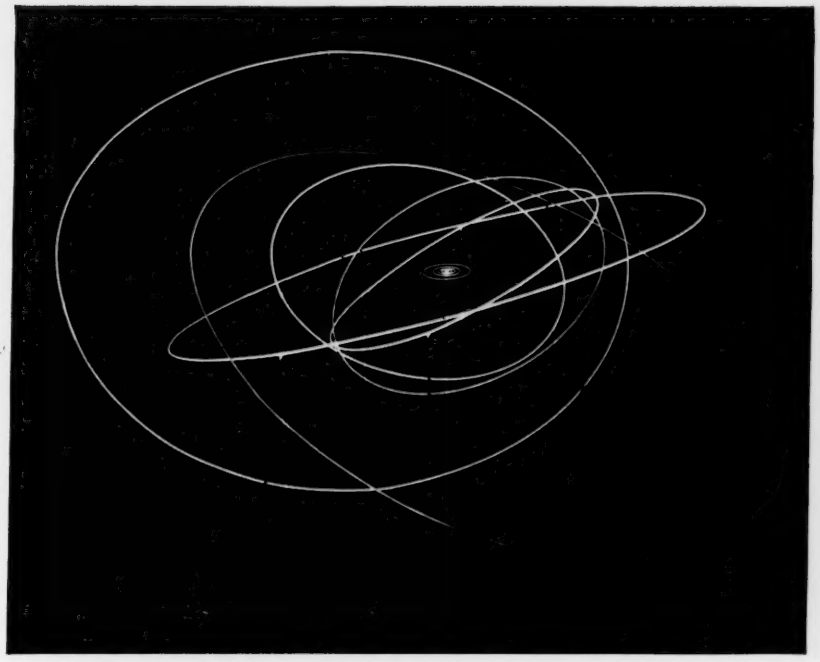
As soon as these plates were developed, and while they were still wet, I scanned them quickly with a low-power magnifying glass. Another object was found about 35 minutes of arc west of the one near the ephemeris position of J X. A second look at the earlier plates of that region showed the western object on them also, very close to the edge of the field. Both objects were of the 19th magnitude, fainter than the other satellites. J IX is a little brighter than X, and XI is still brighter. Satellites VI, VII, and VIII are much brighter than J X (two magnitudes or more) and could not be mistaken for it. Thinking that all the other satellites had been located, I at once suspected that this western object was a new satellite and, with the help of Dr. L. E. Cunningham, of Leuschner Observatory, who was observing at the 60-inch, followed it carefully for some days, to be sure it was not a minor planet. In the meantime, I neglected to follow the eastern object, which had been labeled J X in my observing book, on account of its proximity to the ephemeris place for that satellite.

As soon as I was convinced that the western object was a satellite, it was announced to Harvard (HAC 1147), and a letter was sent to Dr. Musen, giving him more details of the observations. As soon as he saw the announcement card, and before receiving my letter, he realized that the object I had been following was J X, traveling in the orbit used for the ephemeris but nearly 20 days behind schedule. He at once notified Harvard and me. When he got my letter saying J X had been located near its ephemeris place, his message to Harvard was recalled. When his letter reached me, I at once measured the plates of the supposed J X and found that, while that object (the eastern one) was close to the path of J X, it was moving relative to Jupiter in the opposite direction and therefore could not be J X. This information was sent at once to the Cincinnati Observatory, which then told Harvard to release the announcement that the "new" object really was J X (HAC 1152).

As soon as the moon, which had been too bright for direct photography, was out of the way, another photograph was obtained, which showed that the eastern object was probably a new satellite, not a minor planet. This was announced on HAC 1154. Another observation on November 2nd settled the identification

and gave enough data for the computation of an orbit. Dr. G. Van Biesbroeck, who had been informed of the position of the new satellite, observed it at the McDonald Observatory on October 31st, November 2nd, 3rd, and 4th. Since then, additional photographs have been obtained with the 100-inch telescope on December 1st and 2nd.

The preliminary orbit indicates that the new satellite has a period longer than 600 days, and moves in the retrograde direction. It is, therefore, one of the outer group of Jovian satellites, which includes VIII, IX, and XI. These satellites are in the mean about 14 million miles from Jupiter, twice as distant as the nearer group with direct motions, which includes VI, VII, and X.



The complexity of the orbits of Jupiter's outer satellites is shown by this model, which does not include Jupiter XII. As with the new satellite, the outermost move in the east-west or retrograde direction. Note the small size and common plane of the five inner moons. Mount Wilson photo.

THE UNIVERSITY OF MICHIGAN OBSERVATORIES

(Continued from page 78)

Portage Lake is a staff building which provides living and work quarters (*Sky and Telescope,* February, 1950).

Under the supervision of Freeman D. Miller, the Schmidt telescope is being employed for galactic and extragalactic studies. His work is with photored star counts, objective-prism spectra of stars with determined proper motions, and photored isophotes of the larger, irregular galaxies visible in this latitude. Stanley P. Wyatt is working on blue and red isophotes of bright elliptical galaxies. Using other stars of known absolute magnitude in the large Schmidt field as comparisons, Dr. Aller is working on absolute intensity variations at different wave lengths in the spectra of long-period variable stars.

McMATH-HULBERT. At Lake Angelus the small dome houses the Francis C. McMath reflecting telescope, a Cassegrainian with two interchangeable secondaries giving equivalent focal lengths of 50 and 100 feet. Recently, it was used with a Perkin-Elmer infrared spectrometer to observe solar limb darkening and spectral energy distribution out to 10 microns wave length. As already mentioned, it is at present equipped with a photoelectric photometer and interference filters to measure the absolute intensities of monochromatic images of planetary nebulae.

The 50-foot tower contains two main instruments that can be operated simultaneously: a conventional spectroheliograph that makes the well-known McMath-Hulbert motion pictures of solar phenomena in monochromatic light; and the Stone radial velocity spectroheliograph that measures motions in the line of sight. The films are all standardized, and particular attention is being paid to obtaining accurate light curves of flares and to their correlation with geomagnetic disturbances, in collaboration with the National Bureau of Standards and the Cornell University radio astronomy project.

The McGregor building contains, in addition to the 70-foot tower telescope, an instrument shop, laboratory, offices, darkrooms, and library. The tower telescope itself may be used interchangeably with lens optics and an all-mirror system, and with focal lengths of 50 or 100 feet. These give direct solar images 5½ and 11 inches in diameter. The spectrograph room houses three interchangeable spectrographs: a 25-foot Littrow, an all-reflecting infrared spectrometer with photoconductive cells as detectors, and the recently installed echelle spectrograph that permits the photography of about 4,000 angstroms of the spectrum on a single exposure, with a dispersion of 3.5 millimeters per angstrom and a resolving power of about 300,000.

The McGregor tower observations are concerned with the physics of the sun and the earth's atmosphere. In this tower, high-dispersion spectra of solar details are made simultaneously with the recording of their motions in the 50-foot tower. A duplicate of the infrared spectrometer is in operation at the Snow telescope of the Mount Wilson Observatory, and the Lake Angelus instrument is now used chiefly for development and experimentation with new types of infrared detectors. The initial exploration of the infrared solar spectrum culminated in the publication of an entire atlas of that spectrum. Current infrared work, concerned with the limb spectrum, has already resulted in the discovery of carbon monoxide in the sun. The studies include as well the abundance and vertical distribution of various constituents of the earth's atmosphere, such as methane and carbon dioxide.

LAMONT-HUSSEY. With the 27½-inch refractor that he installed in 1927, R. A. Rossiter has discovered over 8,000 visual double stars during the past quarter of a century. The instrument was also used by E. C. Slipher, of the Lowell Observatory, to obtain remarkable photographs of Mars during that planet's 1939 opposition (*The Telescope,* September-October, 1940). Recently completed is a three-year hydrogen-alpha survey of the southern sky carried out by Karl G. Henize with the Mount Wilson 10½-inch camera and objective prism. This instrument has now been returned to the United States.

OPTICAL SOCIETY MEETING

The spring meeting of the Optical Society of America will be held at the Hotel Statler, New York, on March 20-22. A special feature is the Adolph Lomb memorial lecture, by Dr. W. D. Wright, of the Imperial College, London.

The meeting will be open to all interested persons. Non-members may get copies of the program from the secretary, Dr. Arthur C. Hardy, Massachusetts Institute of Technology, Cambridge 39, Mass.

NEWS NOTES

By Dorrit Hoffleit

C. O. LAMPLAND DIES

The assistant director of the Lowell Observatory, Dr. Carl O. Lampland, died at Flagstaff, Ariz., on December 14th at the age of 78. He was born in Minnesota and educated in Indiana, and was an astronomer at Lowell from 1903 on.

Dr. Lampland will probably be best remembered for his investigations of the principal planets, although he also did significant work on minor planets, comets, and galaxies. Few modern astronomers have contributed as much to planetary astronomy as did Dr. Lampland. He was one of the early advocates of the theory that life on Mars is possible, and in 1907 won the medal of the Royal Photographic Society for the first photograph showing the elusive canal-like markings on that planet.

One of his most important contributions was his collaboration with W. W. Coblentz in 1924 on the determination of the temperatures of the planets, a difficult and pioneering job, in which thermocouples were used to detect variations in the heat radiated from various portions of a planet's surface. Mars was found to have a temperature not adverse to the maintenance of life, whereas Jupiter was found to be exceedingly cold, possessing practically no internal heat of its own, contrary to the current opinion of the time.

Dr. Lampland was the first, in 1921, to suspect changes in the appearance of the Crab nebula, and these were later definitely verified by Mount Wilson photographs.

As soon as Pluto was discovered at the Lowell Observatory in 1930, Dr. Lampland began systematic photographic observations of the planet at the 42-inch reflector and worked out its orbit. At the time of his death, he was again busy on computations to improve Pluto's orbit, in co-operation with Yale and the U. S. Naval Observatory.

RADIO STAR DISTANCES

F. G. Smith, of Cavendish Laboratory, has attempted to measure parallax and proper motion for the four brightest radio stars listed here last month. The results are negative, but the absence of any detectable motion suggests that these distances are all greater than half a parsec. While his results may seem very crude to the average optical astronomer, the discussion of how they are obtained (presented in *Nature,* December 1st) is very reminiscent of the early history of parallax determination, in the times when many instrumental, atmospheric, and other errors were not yet recognized.

Meanwhile, a Russian, I. S. Shklovskii, analyzing available published material on radio stars, estimates (as reported in ***Physics Abstracts***) that these objects are about 30 times as numerous as "optical" stars in the vicinity of the sun. Each may be of less than 1/20 the sun's mass, and consequently fainter than optical absolute magnitude 24. Shklovskii believes the presently observed radio stars are not farther away than three parsecs, about as far as Sirius and Procyon. Surface temperatures are probably between 1,000° and 2,000° C., with masses intermediate between large planets and very faint red dwarfs. Infrared spectra of radio stars may provide essential information in this problem.

COSMIC RAYS IN THE SUBWAY

To filter out less energetic cosmic ray particles than the meson, Dr. Morris Shamos, of New York University, estimated that his detecting apparatus should be shielded by tons of lead. It was cheaper to conduct the experiments under 140 feet of rock, in the 8th Avenue Independent subway station at 190th Street in New York City. After the underground measurements had been completed the same apparatus was used in an 11th-floor New York University laboratory. Meson intensities were 40 times greater above ground, furnishing evidence in favor of H. A. Bethe's theory of collision loss. Professor I. Hudes, of Brooklyn College, participated in the experiments.

The worst impediment to the subway observations came from dust, not ordinary dust but iron particles worn away from the trains' brake shoes. The apparatus, consisting primarily of Geiger counters, was housed in a wooden shed on the southbound platform and operated continuously for eight months.

IN THE CURRENT JOURNALS

SOLAR FLARES, by John W. Evans, **Scientific American,** December, 1951. "The sun is not ordinarily news, but once in a long while it crashes the headlines like an earthquake. Radio transmission fades out; Northern lights are seen from Mexico City; Western Union teletypes clatter out meaningless gibberish."

FRED HOYLE'S UNIVERSE, by Ralph E. Williamson, **Journal,** Royal Astronomical Society of Canada, September-October, 1951. ". . . the subject matter [of a series of lectures by Dr. Hoyle presented by the Canadian Broadcasting Corporation] consisted of about 20 per cent. pure fact, about 30 per cent. of working hypotheses, and the remaining 50 per cent. was devoted to pure, untested theory . . . almost without exception, Hoyle's own."

THE FIRST HALF OF THE TWENTIETH CENTURY, by W. M. Smart, **Monthly Notices,** Royal Astronomical Society, Volume 111, No. 2, 1951. "It might have been anticipated in 1900 that these problems, many of them of an ancient vintage, would have been solved to our general satisfaction by this time; although it is true that a very high degree of observational accuracy has now been attained in many departments, yet this increased precision has frequently pointed the way to new difficulties of interpretation and suggested new problems for investigation."

THE ETHER AGAIN

With the introduction of Einstein's special theory of relativity in 1905, the previously popular concept of an all-pervading ether was abandoned as being incompatible with relativity principles. Now, in a letter to *Nature* (November 24, 1951), the question is revived by one of the physicists who has contributed much to the modern development of the quantum theory, P. A. M. Dirac, of St. John's College, Cambridge, England.

He points out, whereas the perfect vacuum has no matter in it and no fields, it represents an idealized state, not attainable in practice. Quantum mechanics require profound alterations in the theoretical ideas of the vacuum. "It is no longer a trivial state, but needs elaborate mathematics for its description."

The original ether concept was that at each point in a region of light propagation there must be an ether, moving with some velocity, presumably less than that of light. In a new theory of electrodynamics, Professor Dirac finds a velocity necessary at all points in space-time — if there is any electric charge it must flow with this velocity, and in regions where there is no charge it is the velocity with which a small charge would have to flow if it were introduced. He concludes:

"It is natural to regard it as the velocity of some real physical thing. Thus with the new theory of electrodynamics we are rather forced to have an aether."

IS ANTARES ELLIPSOIDAL?

Dr. David S. Evans, of the Pretoria Observatory, South Africa, measured the variation in the intensity of the light of Antares while it was being occulted by the moon on June 27-28, 1950. Analyzing his records, he finds that the observations cannot be fitted to the assumption that Antares A is a single symmetrical star. The observations would be well satisfied if it were a binary with components of 0.027 and 0.016 seconds of arc apparent diameter, the companion being three magnitudes fainter than the primary. But this assumption would call for an unlikely low temperature for the companion. Dr. Evans finds that a preferable alternative would be that Antares is pulsating and has an ellipsoidal form.

Astronautics Looks Ahead

"ASTRONAUTICS is the new science of flight beyond the atmosphere and travel to other worlds." Thus begins a press statement by the British Interplanetary Society, organizers of the Second International Congress on Astronautics, held in London early in September, 1951, with its chief purpose and achievement the establishment of the International Astronautical Federation.

The statement further remarks: "Within the next decade or so, rocket performance will have advanced to a stage making possible the establishment of an 'earth-satellite vehicle,' in a stable close orbit around the earth. This will be the first great milestone on the road to the stars. Thereafter, at intervals within the next century the world will see:

Flights by piloted rockets several thousand miles out into space.

Flights circumnavigating the moon, without landing on its surface, first by robot projectiles carrying television, later by piloted craft.

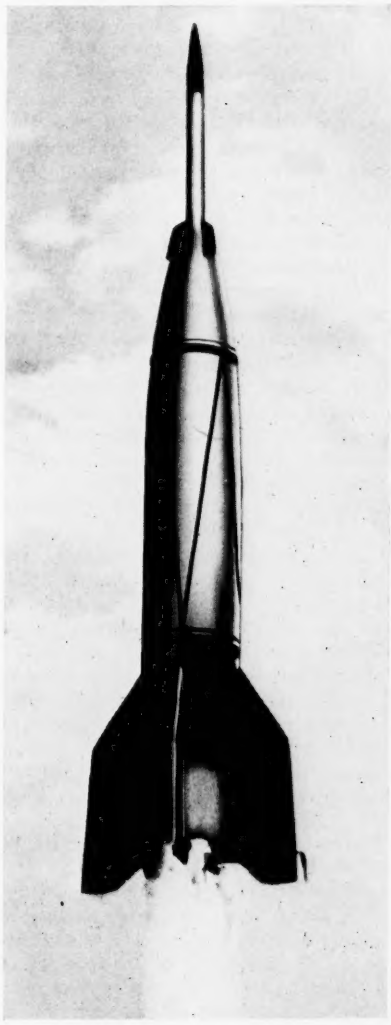
Flights to the moon by piloted spaceships, landing tail-first on its airless surface using the braking effect of their rocket jets, then taking off again and returning to Earth (where a safe landing may be made by using wings within the atmosphere).

Flights, similar to those to the moon, to the other planets of our sun's family — first to Mars and Venus, because they are the nearest and most easily attained.

"At some much more distant future date, no doubt the planets of other suns — the distant stars — will be visited. Such interstellar travel, however, will involve the solution of even greater technical problems than the admittedly vast ones remaining to be overcome before we can travel even to our nearer neighbors in space.

"The above program is nothing less than the greatest adventure still awaiting mankind. When it will be carried out depends mainly on the funds and facilities made available for the task. Astronautical enthusiasts expect the first piloted return flight to the moon to take place before the end of the present century — about as far ahead in time as Bleriot's cross-Channel flight is behind us. It could probably happen in half that time if a concerted attack were made on the problem, using facilities on the same grand scale as those employed to make the atomic bomb. Few would deny that it is, fundamentally, a more worthwhile objective.

"There are just as good reasons for man's desire to visit other worlds as there were for his exploration of the surface of his own. They are, essentially, the same reasons. It is to be hoped that he will eventually act on them for peaceful purposes, through the medium of some international co-operative organization interested in the project for its own cultural value, rather than because of any military or nationalistic motives. One way or the other, however, space flight is likely to be the next major technical achievement of our species. It will usher in a new age of unprecedented experience and knowledge, perhaps even of wisdom, when terrestrial affairs are viewed for the first time in their true perspective, against the backcloth of the universe."



A two-stage "Bumper" rocket taking off at White Sands Proving Ground, N.M. It leaves its launching platform at approximately a 10-degree angle to counteract the rotation of the earth. The thin, pencil-like nose is the WAC Corporal, which is released after the missile is approximately 20 miles high. It continues on its own power and has attained a record 250-mile altitude. The "Bumper" program is carried on by the General Electric Company for the Army ordnance department. Photograph courtesy "Ordnance," journal of the American Ordnance Association, Washington, D. C.

The annual report of the society contains a detailed account of the congress. The chairman of the business sessions was Dr. Eugen Sänger, president of the provisional committee of the International Astronautical Federation. Dr. Sänger was elected the first president of the federation, and it was planned to work out the final details of a constitution for ratification in 1952. Co-founders of the federation are 14 societies, in Argentina, Austria, France, Germany, Italy, Spain, Sweden, Switzerland, England, and the United States.

The four member societies in this country are: American Rocket Society, 29 West 39th St., New York 18, N. Y.; Detroit Rocket Society, 682 S. Waterman Ave., Detroit, Mich.; Pacific Rocket Society, 1128 Fair Oaks Ave., S. Pasadena, Calif.; Reaction Research Society, 3262 Castera Ave., Glendale 8, Calif.

The technical sessions of the congress heard papers chiefly by English and German rocket technicians, on the "first and essential task in the conquest of space," the satellite vehicle. All the contributors believed that interplanetary flight must, or at least should, involve refueling at some kind of orbital base, whether it be a space station or simply a rendezvous position for a fleet of tanker rockets.

Theoretically, a rocket circling the earth at the right speed would remain at a constant distance, in a state of equilibrium. The outward centrifugal force would be balanced by the downward pull of the earth's gravity. The nearer such a satellite might travel to the earth's surface, the more rapidly it would have to move to maintain itself. Just outside the atmosphere, a few hundred miles up, the required speed is about 18,000 miles per hour, nearly four times the speeds so far attained in actual flights. Such a rocket should need little if any power, for it would be beyond the resistance of the earth's atmosphere. Ideally, it should be able to shut off its motors and remain orbiting the earth forever in perfect safety. The British Interplanetary Society lists four practical and immediate uses to which such a satellite rocket could be put:

1. As a research observatory beyond the atmosphere, for physicists and astronomers, especially to detect primary cosmic rays.

2. As a meteorological observatory, from which weather systems could be

seen developing in the lower atmosphere.

3. As a radio relay station, especially for ultra-short-wave, including television, transmission around the earth.

4. As a military base for the radio guidance of missiles over long ranges, for reconnaissance, or even the launching of projectiles.

The contributions to the symposium on satellite vehicles appeared in the November, 1951, issue of the *Journal* of the British Interplanetary Society. Included is a paper by Dr. Lyman Spitzer, Jr., of Princeton Observatory, who sought to focus attention on what promises to be the most practical means for interplanetary flight in the near future. The following is comprised of excerpts from his paper, which was entitled, "Interplanetary Travel between Satellite Orbits." Dr. Spitzer acknowledges the earlier proposals of some investigators of several of the ideas discussed here, such as Oberth's proposal of a rocket propelled by an ion beam, powered by solar energy.

THE POWER-WEIGHT RATIO needed to give a ship an acceleration depends only on the acceleration itself multiplied by the velocity of the ejected propellant gas. As a reasonable acceleration we may take 0.3 cm./sec.^{2}, which would make it possible to escape from a close circular orbit about the earth in a few weeks and to reach Mars a few months later. The velocity of the ejected gas may be taken as 100 km./sec. A higher value would require more power, while a lower value would yield a less favorable mass ratio. With this choice of acceleration and gas velocity, the power needed is about a tenth of a horsepower per pound. We shall consider a ship whose gross weight is about 10 tons, since this is probably the smallest size ship that could carry a uranium or plutonium pile. The total useful power must therefore be roughly 2,000 horsepower. If an overall efficiency of one third is assumed in the conversion of heat into useful power, a heat source of 6,000 horsepower must be provided. . . . One may assume that within the next 10 years the design and operation of a small pile, weighing about a ton and producing some 6,000 horsepower of heat, will become entirely practical. Such a pile would consume about two kilograms of uranium 235 or plutonium 239 in a year of steady operation, and nuclear fuel for 50 years of continuous operation would weigh only 100 kilograms, or a tenth of a ton!

What about the dangerous effects of so much radioactivity on the crew aboard the ship? . . . The easiest way to achieve safety from neutrons and gamma rays is simply by distance. One may envisage the main interplanetary ship as a pilotless engine room, with a light control car, containing the crew, attached by wires some 100 kilometers in length. Power and communications could be sent over the connecting wires. . . . If the car containing the crew and control equipment weighed two tons, the wires pulling the car with an acceleration of 0.3 cm./sec.^{2} would be subject to a force of 1.2 pounds. With a safety factor of a hundred the two connecting wires need each have a diameter of only 0.02 inch and would each weigh about 300 pounds, not an excessive contribution to the mass of the ship. . . . If repairs to the main ship became necessary during flight, the power could be turned off and the control car could be drifted up to the spaceship.

A uranium or plutonium pile generates power in the form of heat, and this must be converted into electrical energy. One may visualize a small pile, with heavy water used as a moderator, in which the heavy water is heated up, turned to steam, and used to drive a steam turbine. This turbine then drives a direct-current generator, whose output is used to accelerate the propellant gases. . . . The temperatures of heat input and heat output are taken to be 900° K. and 450° K., respectively, or 1,160° F. and 350° F. With these temperatures, a heat engine has an ideal efficiency of one half, and at a pressure of about 10 atmospheres the steam will liquefy in the condenser. Even at this relatively high temperature, however, the radiating surface required is about 1,000 square yards. One may visualize a thin fin some 30 yards square extending on one side of the ship, radiating the heat produced by the pile.

. . . The production of intense ion currents has been extensively studied in the last decade, and the acceleration of a spaceship by an ion beam seems to offer no particular difficulties. The electrical voltage to be applied depends only on the mass of the ion to be used and the velocity desired. To accelerate nitrogen ions to a speed of 100 km./sec. requires a potential of 740 volts. Nitrogen is indicated as a propellant, since this gas is readily obtained from the earth's atmosphere, and the ship can therefore obtain propellant gases in its circular orbit; this avoids the necessity of bringing tons of propellant up from the earth's surface for every trip. Since nitrogen is probably also abundant in the atmospheres of Mars and Venus and possibly other planets, propellant gases could also be obtained at various points in the solar system.

At the relatively low voltage of 740 volts required to accelerate nitrogen ions, space-charge effects limit the total ion current that can be accelerated. An accelerating area of about seven square yards would be needed to produce an ion beam of the necessary 2,000 amperes and 1,500 kilowatts. This result assumes that the accelerating voltage is applied over a distance of only a millimeter. Two fine-mesh wire screens, made with wires of very small diameter, could be placed this far apart and given the requisite potential difference. Thermionic emission from the wires in the outer screen could add electrons to the beam so that the ejected gases and the ship would remain electrically neutral.

It may be remarked that if the accelerating voltage were increased to 100,000 volts, the ion velocities would be about 1,000 km./sec., and a spaceship could in theory attain a speed of this order after about 100 years of acceleration. At such a speed about 1,000 years would be required to reach the nearest star.

LETTERS

Sir:

It is well known among men who write for the less technical scientific journals that any readable article can be misinterpreted. This was well expressed some years ago by Dr. Henry Norris Russell in his statement that, to avoid misinterpretation, one would have to put the article in the style of a legal document.

To illustrate misinterpretation, consider the two letters to the editor* criticizing the reference to the big Hoba West meteorite in my article, "Weighing Large Meteorites," **Sky and Telescope, X,** 1, November, 1950. Then consider the review of my article by Spencer (**Mineralogical Magazine,** June, 1951), on whose original paper my reference to Hoba was based. Spencer kindly mailed me a copy of the review, and in neither the review nor his accompanying letter did he make or imply any criticism of the points criticized in the letters. He did, however, inform me that at a later date he had changed the estimate of 88 metric tons, quoted in my article, to 100 metric tons.

As the letters on my reference to Hoba are nearly twice as long as the original reference, certainly no more space should be given to a discussion of the subject in Letters. I suggest, however, that any who have questions on the article write me, and I shall be glad to mail clarifying statements.

I wish to suggest also a simple problem on which readers can test their ingenuity. From the dimensions and specific gravity of the big Hoba West meteorite, and the thickness of the surrounding shale, it is easy to calculate that the 88-metric-ton approximation to the weight of the meteorite plus an allowance for the surrounding shale allows for the shale on the assumption that it represents half its volume of meteoric metal. It is easy to show also that the later 100-metric-ton approximation allows for the shale in the same way, excepting that a layer presumably lost from the top by erosion is allowed for as well. It will be interesting to see in how many different ways the problem is solved.

C. C. WYLIE
State University of Iowa
Iowa City, Iowa

*See Letters, **Sky and Telescope,** January, 1951, page 54, and April, 1951, page 134.

Amateur Astronomers

The 1952 General Convention in Dallas

THE Astronomical League convention for 1952 will be held in the Fondren science building, Southern Methodist University, Dallas, Tex., on July 4-5-6. The building is air-conditioned throughout, and convention sessions, as well as council and committee meetings and the exhibit, will be held there. The Texas Astronomical Society of Dallas, Ft. Worth Astronomical Society, Port Arthur Astronomy Club, and Ft. Worth Junior Astronomy Club are co-operating in convention plans.

Persons attending the convention will be accommodated in dormitories on the campus at a cost of $2.00 per night. We will try to make special arrangements for families. Meals may be taken at the dormitories, or at nearby cafeterias and restaurants. Send registration to Mr. Wesley Gilliland, convention treasurer, 3824 Cedar Springs Ave., Dallas 4, Tex.; $5.00 will pay your registration and two nights' lodging, balance due on arrival.

There will be plenty of table and floor display space but wall space will have to be arranged for on a temporary basis. Persons wanting wall space must send in the amount needed and a description of the material not later than June 15th. Dr. Herman C. Sehested, 3223 Westcliff Rd. West, Ft. Worth, Tex., is chairman of exhibits. Anyone sending exhibits ahead of time should write Dr. Sehested, but the exhibit itself should be addressed to Dr. Frank C. McDonald, Fondren Science Building, Southern Methodist University, Dallas 5, Tex. Commercial displays are invited, but no sales shall be made in the building or on the campus.

Other committee chairmen include Mrs. Sehested, hospitality; and Miss Ollie Martin, duplication and distribution, and Ted F. Gangl, publicity, both of Dallas.

E. M. Brewer, convention mgr.
5218 Morningside Ave.
Dallas 6, Tex.

TELESCOPE MAKING FILM

A 16-mm. film with titles, Making an Amateur Telescope, has been prepared by the Amateur Astronomers of the Franklin Institute. It runs for 15 minutes, and can serve to start a discussion among oldtimers or to give the uninitiated a quick look at the field.

It seems as if, in spite of the publicity given to amateur telescopes, there are many people who have not heard and many more who have not seen the whys and wherefores of this pleasant hobby. The film first introduces the Franklin Institute and its observatory. The newcomer is then signed up and started in the workroom. The separate steps in grinding and testing, the making of a pitch lap and the polishing of the mirror, are shown, so that the public can understand what is going on. Parts for a simple telescope are assembled and the finished instrument is directed at the sky.

The movie has already been shown several times, and any groups interested in it are invited to write the undersigned. The cost per showing is $5.00, and time should be allowed to fit your request into the showing dates that are now on hand.

EDWIN F. BAILEY, AAFI
Franklin Institute
Philadelphia 3, Pa.

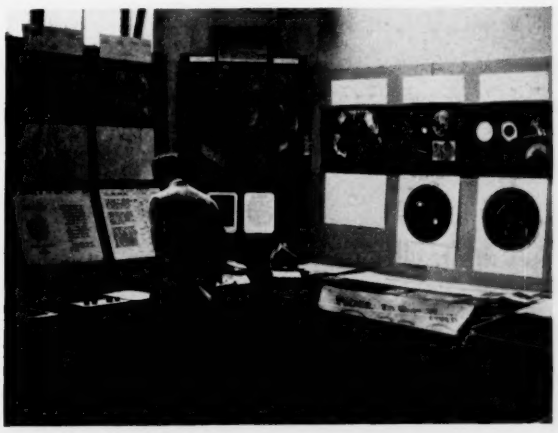
ASTRONOMY FOR FUN

I have had a rather interesting summer with my hobby. In August, 80 adults gathered in the evening on my lawn to see a set of slides projected on the white stucco wall of my house. From time to time I was able to point out objects in the sky which were being illustrated by the slides. This added much to the interest and reality of the lecture. We also used my 6-inch reflector.

Also, I made an astronomy display which was exhibited at Trail, Vancouver, and Rossland. It won the highest award at the Trail hobby show, and so was invited to be shown at the Pacific National Exhibition International Hobby Show at Vancouver [where the exhibit won a special award — ED.]. I mounted the Moon Sets to form a big picture of the moon. Several issues of **Sky and Telescope** were shown.

About 7,000 persons each day for 11 days saw the display at Vancouver. The theme was "Light Means Knowledge." A model of the 200-inch telescope illustrated man's greatest light-"gathering" instrument, while the Bible was the world's greatest light-"giving" instrument. I had my telescope set up on a floodlit photograph of Saturn on a photograph of stars as a background. It looked like the real thing!

ROBERT D. McALLISTER
Box 399, Rossland, B. C., Canada



A portion of the astronomical exhibit made by Robert D. McAllister, which has won several special awards.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: Amateur Telescope Makers and Observers, 8 p.m., Museum of Science. Feb. 6, George A. Davis, Jr., Buffalo Museum of Science, "The Origin of the Constellations and of Star Names.'

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. Feb. 7, joint meeting with Amateur Telescope Makers of Boston. Dr. Bart J. Bok, Harvard Observatory, "The Southern Milky Way."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Texas Bank and Trust Co. Feb. 25, Dr. Frank C. McDonald, Southern Methodist Univ., "Atomic Energy."

Denver, Colo.: Denver Astronomical Society, 8 p.m., Chamberlin Observatory. Feb. 11, Public Information Group program. Feb. 25, Kenneth Steinmetz, "Selections from the Yerkes Collection of Astronomical Photographs."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., Geneva City Hall. Feb. 12, William Siekman, "The Upper Atmosphere of the Earth."

Greensboro, N. C.: Greensboro Astronomy Club, 8 p.m., Science Building, Woman's College. Feb. 13, Dr. Anne Lewis, "A Few Important Names in the History of Astronomy."

Indianapolis, Ind.: Indiana Astronomical Society, 2:30 p.m., Riley Library. Feb. 3, Walter Wilkins, chairman, Technical Division, "How to Make a Telescope."

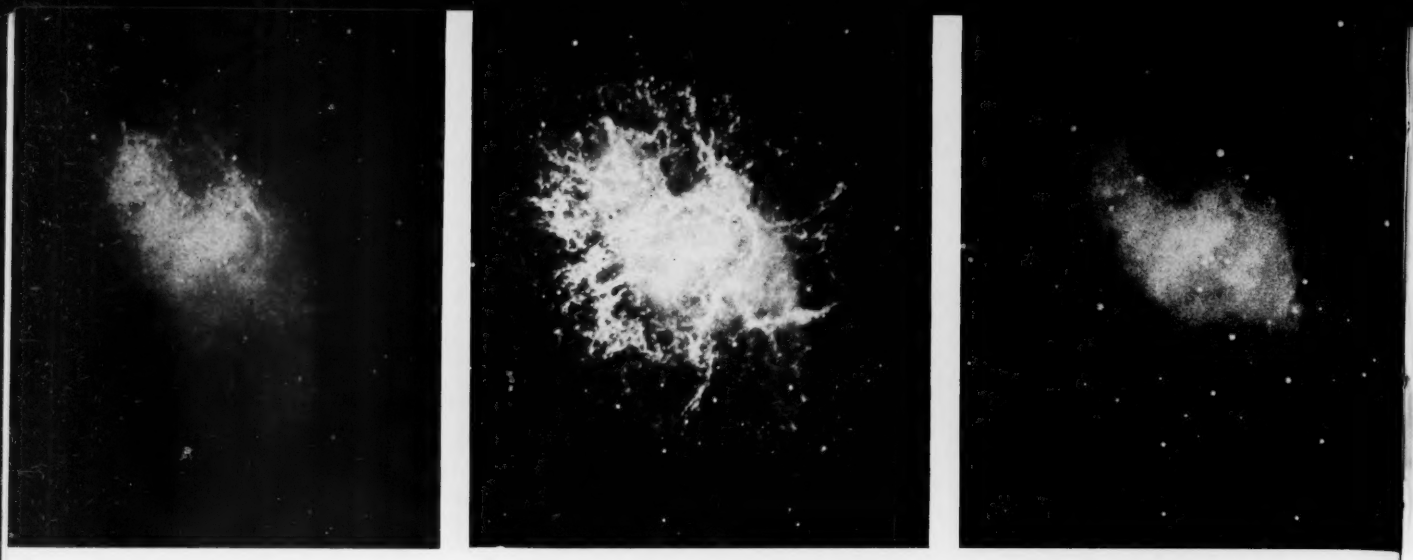
Lorain, Ohio: Black River Astronomical Society, 7:30, Lorain YMCA. Feb. 12, H. M. Valentine, "Motions of the Earth."

Madison, Wis.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Feb. 13, Burt Nelson, "The Sun's Family."

Minneapolis, Minn.: Minneapolis Astronomy Club, 7:30, Library Science Museum. Feb. 6, Maxine Begin, Planetarium program. Feb. 20, Dr. Kent H. Bracewell, "The Legend and Mythology of Astronomy."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Feb. 6, Dr. Raymond H. Wilson, Jr., University of Louisville, "Double Stars."

Rutherford, N. J.: Astronomical Society of Rutherford, 8 p.m., YMCA. Feb. 7, W. B. Savary, Louise Cox, Alfred E. Cox, "Time, Seasons and the Calendar."



Photographs of the Crab nebula in Taurus, by W. Baade with the 100-inch telescope. The center picture, in red light from 6300 to 6700 angstroms, reveals strikingly the dual structure of filaments embedded in a cloud of nebulosity. The left-hand picture is in ordinary photographic light; the right-hand picture is in the near infrared, 7200 to 8400 angstroms, a region of the spectrum in which the filaments are not visible. Mount Wilson and Palomar Observatories photograph.

THE HOTTEST STAR--II

BY OTTO STRUVE, *Berkeley Astronomical Department*
University of California

THE CENTRAL STARS of planetary nebulae are hot and contain much light in the invisible ultraviolet portion of the spectrum. This stellar light passes through each nebula, whose atoms are voracious absorbers of the most ultraviolet light they can get. Thus, the hydrogen atoms swallow all, or nearly all, stellar light whose wave length is shorter than 911 angstroms. But in doing so, they must lose their attendant electrons: they become ionized. The gas then consists of nuclei and free electrons, and also, of course, of normal neutral atoms — all rushing about hither and yon, with large and small velocities.

From time to time a free electron gets close enough to a hydrogen nucleus to "collide" with it and be captured. When that happens, the newly formed or, as we say, the recombined hydrogen atom spews out some or all of the energy it had originally absorbed from the stellar radiation. When the electron is captured into one of the possible outer orbits of the atom, the radiated energy is less than the energy originally absorbed from the star. An emission quantum of continuous Balmer, Paschen, etc., radiation is formed, which is immediately (within one 100-millionth of a second) succeeded by one or more monochromatic line emissions as the electron "cascades" from one orbit to another, finally ending up in the innermost orbit where it started from when the atom was first ionized (Fig. 4).

This process seems complicated. But by an ingenious application of the principle of the conservation of energy, H. Zanstra realized that the total intensities of all the hydrogen emission lines must equal the intensity of the light of the star originally absorbed by the nebula. Thus, all we need to do is to measure the intensities of the hydrogen lines, allowing by computation for those we do not actually see; their total energy is the same as the central star's radiation of wave lengths shorter than 911 angstroms.

Then, by Planck's law, we find the temperature that the star must have to emit just the amount of ultraviolet light we have found. If the nebula is so tenuous that it does not absorb *all* the starlight short of 911 angstroms, then the intensities of the hydrogen lines register only a fraction of the true amount of ultraviolet starlight, and the real temperature of the star is higher than that we have just computed.

Zanstra has perfected this method and has extended it to other atoms, such as ionized helium. The results have in general indicated high temperatures for the exciting stars — of the order of 50,000°, or even more.

In recent years, K. Wurm in Germany has made a special study of the planetaries, including the determination of stellar temperatures by the Zanstra method. In a new book, *Die Planetarischen Nebel* (Akademie-Verlag, Berlin, 1951), he has discussed in detail the rather large differences which are often obtained for the same central star when several modifications of the Zanstra method are used. For example, in the planetary NGC 7612 the original hydrogen method gave, according to Louis Berman, 43,000°, while the modified ionized helium method employed by Wurm gave 180,000°. Both values are high, and there is little doubt that the central star is hot. But the discrepancy is much too large to be attributed to errors of observation.

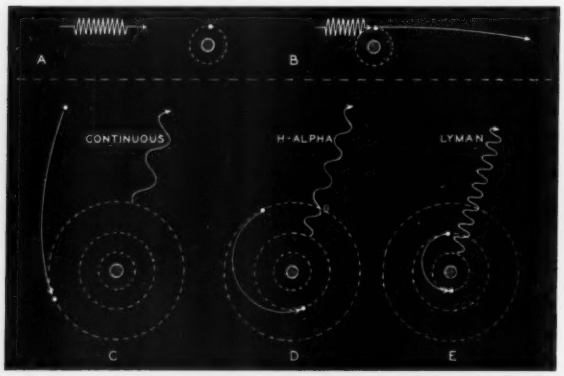


Fig. 4. In parts A and B, invisible ultraviolet light from the central star collides with a neutral hydrogen atom with its electron in the lowest Lyman orbit; the electron is removed to free space leaving a stripped (ionized) nucleus, the star's radiation being used in the process. Subsequently, the atom radiates (C) continuous light when it captures an electron; (D) H-alpha light as the electron drops to the lowest Balmer level; (E) Lyman ultraviolet light as the lowest Lyman orbit is reoccupied. The sum of the intensities of radiations from C, D, and E, equals the intensity of the incoming radiation in A.

Wurm believes that the planetary nebulae are limited in size and mass, and are not simply the luminous portions of vast gaseous masses which merge with the substratum of interstellar matter. When a nebula is tenuous and relatively thin, the ionized helium atoms may still absorb all the appreciable stellar radiation short of wave length 228 angstroms, which is the so-called Lyman limit of ionized helium. Since a very hot star, say of 100,000°, has its intensity maximum at 300 angstroms, there is plenty of this radiation available to produce strong lines of ionized helium by recombination. At the same time, the longer-wave stellar radiation between 228 and 911 angstroms — the latter being the Lyman limit of hydrogen — may not all be absorbed by the nebula, as shown by Fig. 5. If an appreciable fraction passes through the nebula, the hydrogen method must give too low a temperature, while the helium method should be approximately correct.

Hence, Wurm generally prefers the higher values. For NGC 7662 he adopts about 120,000°.

It should be mentioned that Wurm's idea of a limited extent of the planetaries, and an incomplete absorption by hydrogen atoms of stellar radiation below 911 angstroms, is not shared by all astronomers. Greenstein and Page have concluded that the planetaries are much larger than they appear, and that the size of the disk as observed in the visible glow of hydrogen is determined by the distance at which complete (or nearly complete) conversion of stellar ultraviolet radiation into visible hydrogen line-emission takes place.

Even more remarkable than the central stars of the normal planetaries is the hypothetical exciting star of a closely related object — the Crab nebula. This remarkable gaseous mass is the remnant of a supernova which exploded within our Milky Way system in the year 1054, as recorded in several Chinese and Japanese chronicles. This "guest star" reached an apparent magnitude brighter than Venus at her greatest brilliance, and it remained visible for two years. The nebula, which started expanding in 1054, is still growing in diameter, and from the observed rate of the expansion J. C. Duncan and, more recently, N. U. Mayall and J. H. Oort, as well as W. Baade, have deduced a distance of 3,000 to 5,000 light-years, with 3,000 perhaps the best.

Strangely, there is no conspicuous central star! Baade and especially R. Minkowski have carefully examined all suitable faint stars whose images fall within the nebula. Two 16th-magnitude stars are located near the geometrical center of the gaseous mass. One is quickly eliminated because of its very ordinary spectral type, *G*4, but the other resembles the spectrum of the Case Institute star, BD +28°4211, which we

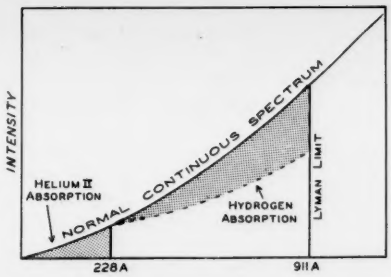


Fig. 5. A sketch to show the effect on the spectrum of the nebula when ionized helium (He II) atoms absorb all energy of wave lengths shorter than 228 angstroms, while hydrogen atoms may absorb only a part of the radiation shorter than the Lyman limit at 911 angstroms.

discussed last month: it shows only a continuous spectrum, without any lines. Although this star is not strikingly blue, as is BD +28°4211, but rather imitates the energy distribution of a star with $T = 20{,}000°$, we have already seen that not much confidence can be placed upon such color temperatures.

The most remarkable thing about the Crab nebula is its large luminosity. The photographic brightness of the exciting star must be seven or eight magnitudes fainter than the whole nebula. Both Minkowski and Baade have stressed this fact. It cannot be explained by absorption of starlight within the nebula, because star counts in this region of the sky show that the nebular absorption is small.

Minkowski had already, in 1942, derived a temperature of 500,000° for the surface of the exciting star. Its radius is only 1/50 that of the sun, and its total luminosity is 30,000 solar units. Because of the unusual character of these values, Minkowski's work was little recognized. But within the past few months, Wurm has published in the *Naturwissenschaften* a new discussion of the entire problem and has substantially confirmed Minkowski's earlier conclusions.

Baade's direct photographs with color filters show that the nebula consists of two parts: a large amorphous shell or ellipsoid which has a continuous spectrum and no lines, and an intricate network of lacy filaments which have strong emission lines of relatively low levels of ionization. The amorphous mass is highly transparent, the filaments are less so. According to Wurm, we can think of the filaments as prominences and of the amorphous mass as something resembling the solar corona; the difference is largely one of density.

The filaments alone account for perhaps 20 per cent of the total light of the nebula. Even so, they are five magnitudes, or 100 times, brighter photographically than the exciting star. Yet, as seen from the latter, the filaments cover only about one per cent of the sky. If they were completely opaque to ultraviolet starlight and covered the entire sky of the central star, they would appear to our eyes 100 times brighter still! If we allow for all invisible emission lines of the filaments, they re-emit an amount of energy (originally contained in the star's own continuous spectrum below the Lyman limit at 911A) that is 100,000 times greater than the

The planetary nebula NGC 3132, known as the "eight-burst planetary," photographed at Harvard Observatory's Boyden station.

whole visible light of the star between 3000A and 7000A. Referring again to some Planck curves similar to those of Fig. 1 (last month), we find that only when the temperature is 600,000° is there such an enormous preponderance of the ultraviolet over the visible stellar radiation.

Despite this high temperature, the spectrum of the filaments is not especially unusual. Their density is sufficiently great to cut down the ionization. According to Wurm, they contain about 10,000 or 100,000 atoms per cubic centimeter. (The earth's atmosphere at sea level contains 3×10^{19} atoms per cubic centimeter; interstellar matter has only one atom per cubic centimeter.) According to Minkowski, the spectrum of the filaments is anomalous in showing strong lines of neutral and ionized helium, while the hydrogen lines are relatively weak. This indicates a low abundance of hydrogen in the nebula — suggestive of nuclear processes in the original supernova outburst. But this does not materially affect Wurm's argument.

The amorphous gas cloud is, however, quite unusual. Its density corresponds to about 100 atoms per cubic centimeter. Far away from any star a gas at this density would be about half ionized. But in the vicinity of a star whose temperature is half a million degrees, the ionization must be even more advanced than in the solar corona. Ordinarily, we express the ionization in terms of energy required to ionize a representative atom. Thus, the reversing layer of the sun has an average ionization of about eight volts, indicating that ordinary elements, like neutral iron or hydrogen, are only partly ionized. Most atoms are not ionized. The solar corona, however, has an ionization of about 300 volts. Iron has lost as many as 13 of its 26 attendant electrons. Wurm belives that the ionization of the amorphous part of the Crab nebula is of the order of 1,000 volts — a state at which the gas produces no emission lines in the visible region of the spectrum.

The continuous emission of the nebula results from the large accelerations and decelerations which the individual free electrons of the highly ionized gases experience in their random flights. As they approach one another, or some atomic nucleus, they move in hyperbolic orbits, just as an interstellar comet would do if it should approach the sun. In doing so, each electron experiences an acceleration, and this, in accordance with the principles of classical electrodynamics, produces a glow, not of a single, discrete wave length, but of all the wave lengths in the spectrum. In short, a continuous spectrum is produced.

If we are to answer the question of our title, the best we can do now is to point to the star that excites the Crab nebula to shine. That, at any rate, is the opinion of many astronomers. But a trace of doubt still lingers on. What about the black-body assumption? It, too, plays a fundamental role in Zanstra's method, and in its more recent elaborations. Then, again, Wurm's clever comparison of the sun's corona and prominences with the Crab's amorphous and filamentary parts invites further discussion.

The corona has an ionization of some 300 volts. Does that justify our saying that the sun is very hot? All one can conclude is that the temperature of the corona itself, as defined by the random motions of its particles, is about one million degrees. If the sun's light is responsible for this temperature, then it must possess an enormous excess of radiation below the Lyman limit, and in that case its spectral energy curve would be about as far from a black body as one could imagine. But some astronomers believe that the origin of the corona's temperature is not to be found in the normal radiation of the sun, but in some other causes: the infall of interstellar matter, the action of prominences, the magnetic properties of sunspots, and the like. If they are right, then we should be prepared to find that the light of the Crab nebula may not be caused by the conversion of ultraviolet starlight into visible nebular luminosity. The temperature of the exciting star should not be taken too literally.

Dr. Minkowski has recently emphasized the fact that the Crab is a strong source of radio waves. We do not definitely know whether the nebula or the central star is responsible for this effect of "cosmic static," but there is a possibility that the high intensity of this extremely long-wave radiation will make it necessary to discard the assumption of a black-body distribution of energy in the source. This would perhaps help in bridging the gap between the solar corona and the Crab nebula. This gap is really enormous. The total visible light of the corona is about one one-millionth of the light of the sun. The total visible light of the Crab nebula is at least 1,000 times greater than the light of the associated central star.

TERMINOLOGY TALKS

J. Hugh Pruett

"Great Meteoric Procession"

A spectacular meteoric display, quite unique in astronomical history, was observed on the evening of February 9, 1913, from a fairly narrow but very long band of the earth's surface. This band extended from western Saskatchewan in Canada in a general southeasterly direction through Pennsylvania, out over the Atlantic in the vicinity of the island of Bermuda, north of the Guiana coast of South America, and finally off the easternmost tip of Brazil slightly south of the equator. The last two positions were reported by officers of the S.S. *Bellusia* and the S.S. *Newlands*. The total "ground path" was over 5,000 miles long, or one fifth the distance around the earth.

A great deal was written about this meteor shower during the few years following its occurrence. Occasionally, during more recent years, astronomical magazines have carried articles concerning it. Here in Terminology Talks we shall attempt merely to review some of the reports and theories. Observers, even from the same vicinity, disagreed greatly in their descriptions, and learned writers later failed to agree as to the explanation of the phenomenon.

For completeness of description, together with maps and observers' drawings, one should read the 70 pages of interesting material by Dr. C. A. Chant, of the University of Toronto, in the May-June, 1913, *Journal* of the Royal Astronomical Society of Canada.

As the name suggests, the spectacle was not a single blazing fireball, but large numbers of them in several groups, all of which traveled along approximately the same apparent path. The time it took for the entire "procession" to pass any locality was variously estimated from three to five — or even more — minutes. Dr. Chant considered 3.3 minutes was about right as viewed from the locality of Toronto.

Let us try to form a composite picture from the descriptions of some of the observers in Canada. The meteors were first seen in the clear sky over a region considerably west of Regina, Saskatchewan, at about 9:05 p.m. EST. They traveled in general from northwest toward the southeast. Some observers said they came up from behind one horizon and finally dipped into the opposite skyline. But others had them appearing and fading out well up in the sky. The leader of the celestial herd was a single huge red fireball, trailing a long fiery tail and scattering glittering sparks profusely. There was general disagreement on the apparent size of this leader. Some said it had a diameter equal to that of the moon, or even larger; others, that it compared with Venus in size. The time it was in sight was variously estimated as from 10 to 60 seconds.

Hardly had this startling, ruddy object disappeared when over the same path came numerous bright yellowish-red meteors traveling close together. Many had streaming, luminous tails and all were profusely throwing off sparks.

(Continued on page 97)

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 86th meeting of the American Astronomical Society at Cleveland, Ohio, in December. Complete abstracts will appear in the Astronomical Journal.

A Versatile Photometer

When a Nicol prism or a piece of polaroid is used as an analyzer in polarimetric measurements, half of the light entering these elements is completely lost. This loss cannot be ignored where stars are concerned, and Dr. John S. Hall, of the U. S. Naval Observatory, has developed an instrument designed to measure simultaneously the polarization, color, magnitude, and spectral type of a star.

A diagram of the apparatus is shown here, together with a photograph of the actual equipment. The analyzer for polarization is a rotating cylinder of calcite, which also separates the light into two equally bright ordinary and extraordinary beams. The ordinary beam is passed directly to the photomultiplier tube of the photometer. The alternating current caused by light from a polarized star (as the calcite rotates) is amplified and presented as a simple sine wave on a Brown recorder. The direct current produced by the same multiplier, proportional to the brightness of the star, is also amplified and recorded. With this brightness measurement and some phasing markers, it is possible to determine both the plane of polarization and its amount.

The extraordinary ray is reflected from a mirror and is made to pass through one of a sequence of four interference filters to a second photomultiplier. The central passbands of these filters are at wave lengths 4220, 4720, 4861 (hydrogen-beta), and 5550 angstroms. Every two minutes, the record of this second photomultiplier contains four separate deflections, one for each of the filters. Three of the four filters are used to measure the star's magnitude in three colors, compared with the color of a carefully controlled artificial star. The 4861 and 4720 measures may be used for spectral classification.

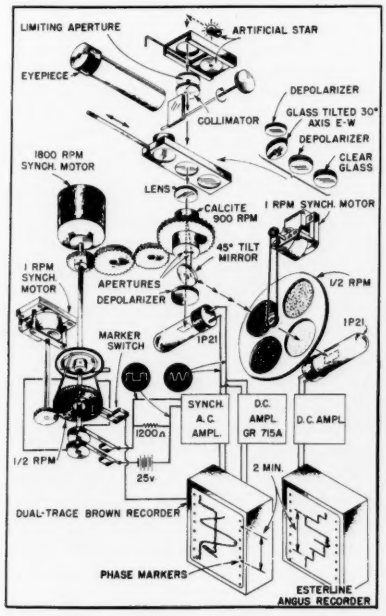
The two multipliers may be calibrated for both polarization and magnitude automatically, by means of the artificial star, while the position of the telescope is being changed. The increase in accuracy and speed of making the observations fully justifies the use of two photomultipliers, three amplifiers, and three recording systems. Preliminary observations of 50 stars show the apparatus to work well for stars of the 10th magnitude and brighter.

Very Young Stars

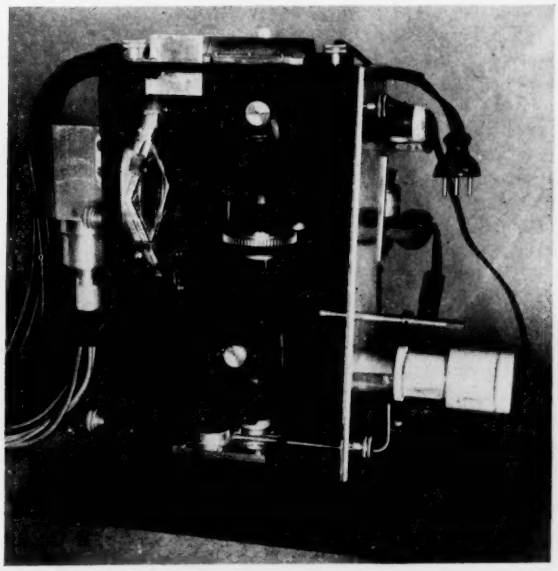
The formation of stars within the astronomical "present" of only 1,300,000 years ago is indicated from studies by Dr. A. Blaauw, Leiden Observatory, Holland, of a loose clustering of *B* stars surrounding Zeta Persei. Unpublished results of far-reaching significance were included in the Henry Norris Russell lecture by Dr. Jan H. Oort, Leiden's director. His title was "Problems of Galactic Structure." He said, concerning Blaauw's work:

"These loose groups, stellar associations, aggregates, or relationships, as they have alternatively been called, are of a quite particular interest. They have been known for a long time, ever since spectral classes have been determined, and several have been extensively studied. It had also been well realized that because of their looseness these clouds of early-type stars must be torn up by the effects of differential galactic rotation in a period of the order of one revolution of the galaxy, and that therefore they must be comparatively young. During the last few years considerable work on the problems presented by the *B*-star clouds has been done by Ambartzumian and his co-workers at the Erevan Observatory. . . . In particular, Ambartzumian has stressed their significance for the cosmogony of the massive stars. The most important new concept that has, I believe, been first suggested by Ambartzumian is that the associations are expanding. And this is not only because of galactic rotation, but also as an essential property of their own. This has proved to be a fertile idea, which seems, in a somewhat unexpected manner, to give an insight into the origin and the meaning of these groups.

"In a still unpublished investigation on a group of *B* stars surrounding Zeta Persei, Blaauw has succeeded in proving such an expansion by direct observation. This loose clustering, measuring about 40 by 20 parsecs, is situated between 12 and 20 degrees southern galactic latitude, at a distance of roughly 300 parsecs. The reality of the relationship between the stars cannot be doubted. However, already in 1944, when he first discovered



Left: A functional diagram that shows the essential parts of the photometer for measuring polarization, color, magnitude, and spectral type. Drawing by Roger D. Stewart.



Right: A photograph of the Hall photometer, including a guiding eyepiece that does not show in the diagram. Some of the apparatus is partially hidden behind the case. Official U. S. Navy photograph.

the group, Blaauw was struck by the fact that the proper motions of the members showed rather unexpected divergences. Recently he has determined independent new proper motions, in the same way as H. R. Morgan has determined the proper motions of his N30 system. These new proper motions confirm the divergences found previously, and prove that the group is expanding at a rate of 0".0028 ±0".0004 (mean error) per year and per degree distance from its center. This surprisingly rapid expansion, of about five kilometers per second for stars halfway the radius of the group, corresponds to an age of only 1.3 million years (with a mean error of about 14 per cent). Low though this age may seem, it is entirely compatible with the age that may be ascribed on theoretical grounds to the most luminous members of the group, like the *O* star, Xi Persei.

"The most straightforward interpretation of these observations is that the members of this group were formed about 1,300,000 years ago as a consequence of a dense conglomeration of interstellar clouds with turbulent motions of the order of five kilometers per second. These turbulent velocities now show up roughly as an expansion of the group, which has already grown very considerably since its birth. Even today the whole region is full of dark as well as luminous interstellar matter. . . . I believe this is the first direct evidence of the birth of stars from interstellar material. A remarkable thing is the extremely short time in which these stars must have contracted from interstellar clouds into actual stars. The available time is only barely long enough for a cloud with a radius of the order of one parsec to contract under its own gravitation.

"It is likely that the Zeta Persei aggregate is rather exceptional in the rapidity of its expansion. At least it is certain that in the other *B*-star clouds for which data are available the expansions are considerably less rapid. By far the longest and best known association of *B* stars is the large Scorpius-Centaurus cloud. The most complete investigation has again been made by Blaauw. It is the only *B*-star group for which the space distribution can be determined. It is considerably larger than the Zeta Persei group, and has a strikingly oblong shape, with a long axis of about 290 parsecs, the other axes being about 100 parsecs and 70 parsecs, respectively. It is tempting to suppose that this aggregate has also formed from a much smaller conglomeration of interstellar clouds, the stars having dispersed as a consequence of the turbulent motions in this agglomeration. The motions are not yet known with sufficient accuracy to determine the amount of expansion, but they suffice to show that it is much smaller than in the case of the Zeta Persei group, probably not much larger than one kilometer per second. The Scorpius-Centaurus cloud does not contain very bright supergiants; the ages of the brightest stars might be estimated to be of the order of 50 or 100 million years. Blaauw has remarked that both the strong elongation of the group and its orientation in space can be understood as the natural consequence of expansion combined with the differential rotation of the galactic system. In fact, if an expansional velocity of one kilometer per second is assumed, the cloud would in 60 million years have gotten the dimensions, the amount of elongation as well as the orientation in space that are observed today."

Members and guests at the 86th meeting of the American Astronomical So

For further background material on stellar associations and their ages, the reader is referred to the article by Dr. Otto Struve, *Sky and Telescope, VIII,* 215, July, 1949.—ED.

The Moon's Ephemeris

Electronic calculators once again have shown the way to more precise astronomical predictions, this time in the position of the moon. Our satellite has always been of great importance as a sensitive test of basic dynamical theory and as a tool in such practical problems as the determination of time and position on the earth. Before the invention of the chronometer, the moon provided the only practical way of determining longitude; now it gives the most accurate methods of determining time and of measuring distance across the ocean.

When the IBM Selective Sequence Electronic Calculator (see *Sky and Telescope,* February, 1951) was dedicated in 1948, the moon's positions were calculated directly from E. W. Brown's lunar theory for 60 half-day intervals from April 24 to May 24, 1948. The program was conducted by Dr. W. J. Eckert, Rebecca B. Jones, and H. K. Clark, of the Watson Scientific Computing Laboratory at Columbia University.

Brown's monumental calculations, which occupied most of his lifetime, consisted of two distinct steps: the lunar theory, and a three-volume set of special tables based on the theory and designed to aid the making of predictions of the moon's future positions. In the SSEC dedication calculations, the tables were bypassed; Brown's equations of more than 1,650 terms were arranged for the calculator and stored in its memory. Then, to compute a position for any date in the past or future, it was necessary only to insert the required time in the machine. The machine automatically evaluated the 1,650-odd terms, and gave the value of the moon's co-ordinates for the date desired, rigorously checked. In seven minutes, tens of thousands of arithmetic operations were performed for each result.

The values computed by the machine represent Brown's basic equations with very high accuracy. The resulting co-ordinates are consistent with the adopted equations with an accuracy of 0.001 second in longitude and latitude and 0.0001 second in parallax, ample ac-

onomical Society, Case Institute of Technology, Cleveland, Ohio, December 27, 1951. Photograph by Howard Studios.

curacy for present needs and serving as a sound basis for applying small future corrections due to possible changes that may be made in the basic equations.

It had been expected to find accidental differences with ephemerides based on the tables, because of unavoidable errors accumulated by rounding off and taking differences. The actual discrepancies, however, appeared highly systematic, and Dr. E. W. Woolard, of the U. S. Naval Observatory, undertook a detailed and laborious analysis to find just how this came about. For the most part, the approximations adopted by Brown in constructing the tables to facilitate their practical use accounted for the differences. But in one case a term was found to have been inadvertently included twice; the resulting error in the moon's predicted latitude is large enough to be detected in observations.

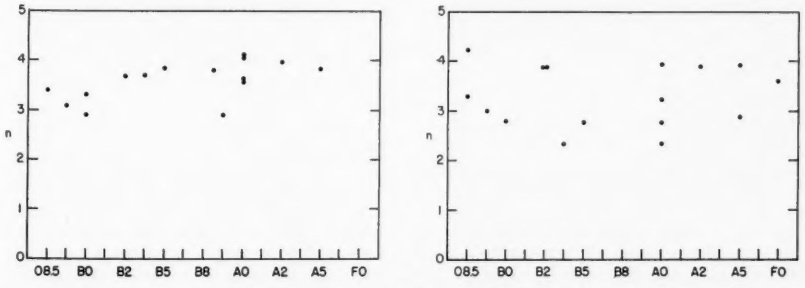
Dr. Woolard's results, together with several needs for a more precise lunar ephemeris, have led both the United States and British nautical almanac offices to consider the possibility of recomputing the moon's positions for 20 years beginning with 1952. About 25 million multiplications would be required for the 15,000 positions involved, but much of the work could be done on smaller electronic calculators than the SSEC.

Mass Distribution in Stars

In the study of stellar structure it is desirable to have an estimate of the precise manner in which the mass is distributed within the star. There is no direct way to obtain this information. However, in the case of a few binary systems in which the stars are moving in close orbits, the figures of the stars are distorted as a result of gravitational forces in the same way that the moon and sun create tides on the earth. These tides cause a small departure of the orbital motion of the stars from what would otherwise be motion in a fixed ellipse. Instead, the orbit is an ellipse whose major axis (line of apsides) revolves very slowly. If the system is an eclipsing binary whose elements are known, it is possible to compute, from measures of the rate of the revolution of the line of apsides, the coefficients describing the manner in which the mass is distributed.

In a study by Leon N. Zechiel and Dr. Geoffrey Keller at Perkins Observatory, a group of eclipsing binary systems of known or suspected apsidal motion was analyzed by the method developed by T. E. Sterne. The most recent available data were used, and the left-hand chart shows the result of the computations, where the ordinate is the effective polytropic index, n, and the abscissa is the spectral type. The value of n is an indication of the degree of central condensation of the mass, a value of $n = 0$ corresponding to a homogeneous mass distribution (uniform density throughout), and $n = 5$ corresponding to a star in which the entire mass is concentrated at the center.

The right-hand chart is constructed from an earlier analysis by H. N. Russell. A comparison shows considerable change in the plot since 1939, due to improved observational data obtained since then. There is an apparent limitation of n to values between 2.9 and 4.1, and a tendency for the lower values to be associated with the earlier spectral types. In a star for which $n = 3.5$, the central density is of the order of 100 times the mean density.



Effective polytropic index versus spectral type: (left) Zechiel and Keller, 1951; (right) H. N. Russell, 1939. Perkins Observatory chart.

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BOOKS AND THE SKY

ROCKETS, MISSILES, AND SPACE TRAVEL

Willy Ley. Viking Press, New York, 1951. 436 pages. $5.95.

THIS BOOK is a revision and enlargement of the author's **Rockets and Space Travel** (1947), which in turn was a revision of **Rockets** (1944). In his foreword the author justifies the present extensive revision by the change in the attitude of the layman since 1944 and by the recent achievements of rocket science, such as the successful launching of a two-stage rocket that achieved the velocity of 1.39 miles per second and a height of 250 miles. Compared with the 1944 publication, the present book has new chapters, especially those giving the story of Peenemunde and White Sands, more material in general, more pictures, better paper, and somewhat better typography. The above works have not been previously reviewed in **Sky and Telescope;** it seems not amiss at this time to give this new volume a general recommendation as excellent for reference, for a summary of rocket developments, and for the interesting tale that it unfolds.

The first two chapters especially should appeal to the astronomer. He will find a few errors, as in the definition of **saros,** but he will be intrigued by the construction of a history of astronomy around speculation on other worlds than ours. He will enjoy hearing again about the moon hoax, and hearing perhaps for the first time about the **prix Guzman,** a prize of 100,000 francs (then $20,000) offered in 1900 to the person or persons first establishing communication with another planet, not including Mars. It seems that Madame Guzman thought it would be too easy to get in touch with the Martians.

Chapters 3, 4, and 5 recount early rocket history, from the invention of rockets by the Chinese, along with gunpowder, about A.D. 1200, through the pioneer researches of Goddard and Oberth. Early objections to the proposals of the latter may give us pause. Some of his scientific critics apparently had difficulty in understanding that the velocity of the rocket can exceed the velocity of its exhaust gases, and that the exhaust gases would accordingly follow along behind. "Two or three well-reputed astronomers" are reported as having argued that there could be no recoil in empty space! If this be so, it should remind us that a scientist has been defined as a person who thinks clearly in only one field, part of the time.

The next five chapters are full of interest for their accounts of early developments by the VfR (Verein für Raumschiffahrt), and of later ones at Peenemunde and at White Sands. The author intersperses these accounts with discussions on such matters as mass ratio and the possibilities of present-day fuels, and an amusing discourse on why H. G. Wells' "Cavorite" gravity shield is impossible. Perhaps the account, as history, falls a little short by overemphasizing the work of Germans, or of practical experiment as opposed to theory — to quote from the author's opening paragraph, "Ideas, like rivers, never have just one source." Many more sources will have to be discovered before a definitive history of the early development of rockets can be written.

The latter part of the book returns again to matters in the special domain of the astronomer. The reviewer is tempted here to pass over the many points that are well presented, and to discuss a few of the points where the author had difficulty with presentation, or tended to perpetuate popular fallacies.

On the determination of one's position in space from observations, the author expresses the usual overoptimism as to the role radar will play, and tends to oversimplify optical observations by indicating that one type will serve to determine heliocentric longitude and another to determine the length of the radius vector. Actually, the problem of accurate position determination will probably more closely resemble present-day observations of minor planets and the use of residuals to improve orbits. Our processes will have to be speeded up greatly, of course, by the precalculation of ephemerides giving angular distances rather than position, and by an improvement in technique where the introduction of electronic gadgetry will probably play a more important role than in the direct determination of distance.

The author shares popular enthusiasm for the "neutral point" (the point where the direct attraction of the moon balances that of the earth), or for the "line of equal attraction," or for the "sphere of influence" of the moon. Such a point, line, or sphere would be significant if the determination of an orbit depended only upon position and acceleration. The great importance of velocity to orbit determination renders their significance almost nil. The difference between the initial velocities required to reach the distances of the moon and of the neutral point, moreover, is only about five parts in 10,000.

Another fallacy perpetuated in the book concerns the "transition velocity" of about 1.5 miles per second. It is thought necessary to impart this additional velocity to a rocket that has taken off from the earth with the velocity of escape, after it has reached a considerable distance from the earth, in order to carry it out to Mars or in to Venus. Actually, very slight increases in the initial velocity will accomplish the same ends. The velocity of escape from the earth is 6.95 miles per second; the velocities hypothetically necessary to carry a rocket out to the distance of Mars or in to the distance of Venus are 7.09 miles per second and 7.12 miles per second, respectively.

The author enlists our sympathy when he tries to explain why, in the first two-stage rocket, the thrust period of the WAC Corporal second stage was begun immediately at the end of the thrust period of the V-2 first stage, at a height of some 20 miles, instead of waiting until both had reached the V-2's maximum altitude of 100 miles. Perhaps the best way of establishing this point is by the use of the method of variation of parameters

in conjunction with the **vis-viva** integral. It may be shown thus that the major axis of the geocentric orbit will be increased most effectively when the velocity is greatest, that is, as near the surface as possible. To express this proof in terms that the layman can understand is a task that we are happy to leave to Mr. Ley. The same relationship enters elsewhere, for example in the Oberth discussion of accelerating a hypothetical rocket into outer space by allowing it first to drop close to the sun and there applying most of the thrust. In another place the author seems to be unaware of the implications of the relationship when he implies that **4g** of thrust is more effective in a horizontal direction than in a vertical direction.

In a discussion of Mr. Ley's interesting book, it seems not inappropriate to mention also the relationship of the astronomer to present-day enthusiasm for interplanetary travel. It is apparent already that there is disagreement on this matter that may attain the proportions of the controversy over the canals of Mars. On the one hand there are the pessimists among us who believe that interplanetary flight will be impossible, because of meteorites, or because of the difficulty of attaining the velocity of escape, or for other reasons, and who believe that others of us, who express an interest in the problem, are wrong to encourage the layman in false and exciting hopes.

On the other hand the optimists among us can point to interesting new problems in rectilinear motion, in orbit determination, in perturbation theory, in the attraction of spheroids, and in the three-body problem, that rockets are bringing for the first time to our serious attention. If pressed, the optimists will probably have to agree with the pessimists that interplanetary flight is more exciting than immediate. But they can nevertheless enjoy Mr. Ley's quotation of Professor Dr. Wilhelm Wundt: "Those not imbued with enthusiasm will as a rule avoid major mistakes but will also miss major accomplishments." The worst pessimists among us will agree with Mr. Ley that interplanetary flight would be a major accomplishment.

SAMUEL HERRICK
Department of Astronomy
University of California, Los Angeles

BRITISH SCIENTISTS

E. J. Holmyard. Philosophical Library, New York, 1951. 88 pages. $2.75.

THIS delightful little book spans the history of British science from the time of Roger Bacon to the beginning of the 20th century. The author, a distinguished historian of science, has chosen 24 leaders of scientific thought to illustrate its development.

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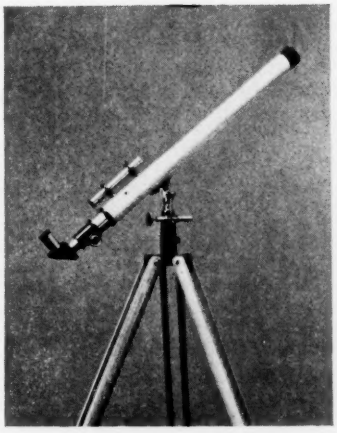

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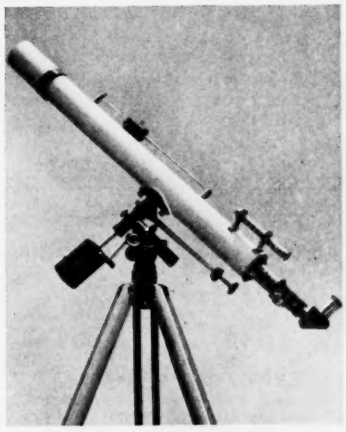

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of the man's work, and of its relation to contemporary thought.

To select so short a list and make it truly representative is a difficult task, but it is hard to cavil at the author's choice. The greatest emphasis is placed on chemists and physicists; one regrets the omission of portraits of the astronomers Flamsteed and Halley and of John Couch Adams. Biologists and geologists are even more thinly represented, and perhaps Lyell, Hopkins, and Bateson might have been included among the portraits. But such a gallery is a matter of personal choice, and none of Mr. Holmyard's subjects could well have been omitted.

The book treats of Roger Bacon, Gilbert, Napier, Harvey, Boyle, Newton, Hutton, Black, Priestley, Cavendish, Dalton, Davy, William Herschel, Faraday, Charles Darwin, Lord Kelvin, Maxwell, Lord Lister, Crookes, Perkin, Dewar, Ramsay, Thomson, and Lord Rutherford.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

CONFERENCE ON THE SUN IN THE SERVICE OF MAN

Proceedings, Vol. 79, No. 4. American Academy of Arts and Sciences, 28 Newbury St., Boston 16, Mass. 1951. 145 pages. $2.50.

IN a prefatory note to this publication of the papers presented at the conference, held at the American Academy of Arts and Sciences in 1951, Dr. Harlow Shapley, chairman of the conference, points out that the sun is the prototype of 40,000 stars among a quarter million of the brightest stars. Its advantages to physics, chemistry, and meteorology lie in its comparative proximity to the earth.

The publication is divided into three parts: the biological utilization of solar energy, sun-earth relationships, a survey of energy sources, needs and utilization. "Energy from Forests," by Hugh M. Raup, Harvard University Forest, is one of the papers in the first part; "Will Our Sun Ever Explode?" is the subject of George Gamow, George Washington University, among five papers in the second part; and "The World's Energy Supplies and Their Utilization," by Eugene Rabinowitch, University of Illinois, is the principal paper in the third part. C. A. F.

FROM THE LIFE OF A RESEARCHER

William Weber Coblentz. Philosophical Library, New York, 1951. 238 pages. $4.75.

THE NAME W. W. Coblentz is well known to those familiar with the science of radiometry or the measurement of radiation. From 1905 to 1945, Dr. Coblentz at the National Bureau of Standards carried out research primarily on instrumental technique and characteristics of infrared radiation from various sources. Among his applications of these results were some of the earliest measurements of planetary and stellar radiation. The former indicated that the noon temperature on Mars may reach 50° F., a result which added to the speculation (not by Coblentz) of life on Mars. Recently, Kuiper, using photoelectric methods in the infrared, has just about put a damper on these always exciting if not well-founded speculations.

In this brief autobiography, Dr. Coblentz first describes his early years on a farm and relates numerous incidents in the development of an outstanding experimental physicist. Later, when telling of his scientific work, the emphasis is upon the sidelights and anecdotes associated with the research, not the research itself. Thus, we begin to fill in the personality and characteristic traits of the scientist which, according to custom, are so carefully removed from scientific reports. Also, disputes and differences of opinion which arose throughout Coblentz' career appear in this informal autobiography.

The author's interest in psychic phenomena, described here for the first time, should be noted. Dr. Coblentz briefly reports on his experiences and experiments among the supernatural. The events discussed in this chapter are clearly on a different level from his physical investigations. Dr. Coblentz, with a background of careful experimental research, concludes that some "unexplained reality" underlies these phenomena. As with the Martian problem, there is ground for speculation, controversy, and investigation here also.

This reviewer has continually been impressed with the discovery that a familiar name in a specialized field actually represents a complete person with all the accomplishments and idiosyncrasies of such. This book goes a long way in doing this for the signature, W. W. Coblentz.

BERTRAM DONN
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NEW BOOKS RECEIVED

ASTRONOMY OF STELLAR ENERGY AND DECAY, *Martin Johnson*, U. S. release 1951, *Dover*. 216 pages. $3.50.

A general reader's outline of facts and theories about the life histories of stars and, in its second part, a student's introduction to problems of stellar radiation. The author's preface is dated December 5, 1948.

IL SOLE, *Giorgio Abetti*, 1952, *Ulrico Hoepli*, Milan. 562 pages. Lire 2500.

This is the second edition of this standard work on the sun, in Italian, by the director of the Arcetri Observatory. The first edition appeared in 1935. The book covers observations of the sun of all types, visual and photographic, the various kinds of spectroscopic studies, and eclipse investigations. It discusses the constitution of the sun, its radiation and temperature, the sun as an astronomical body, and solar-terrestrial problems. There are 238 illustrations, including diagrams and numerous halftones.

PANORAMA OF SCIENCE, 1951, *Webster Prentiss True*, editor, 1951, *Series Publishers, Inc.* 416 pages. $5.50.

A collection of 27 articles on various subjects in science, published mostly during 1950, have been printed in this volume as the annual supplement to the Smithsonian Series for 1951, designed to keep owners of the series and the thoughtful reading public "reliably informed of the steady advance in all branches of science."

BASIC MARINE NAVIGATION, *Bok and Wright*, 2nd edition, 1952, *Houghton Mifflin*. 424 pages. $6.00.

The new edition of this book, which first appeared in 1944, contains rewritten sections describing the *Nautical Almanac*, to conform with changes in that publication, and all celestial navigation problems (Chapters 12-16) have been revised in accordance with the 1952 *Almanac*. Tide and current forms have been added.

GENERAL ASTRONOMY, *Sir Harold Spencer Jones*, 3rd edition, 1951, *Longmans, Green*. 456 pages. $5.75.

This textbook for the amateur as well as the student has been revised and many sections rewritten, by the author, Astronomer Royal of England. The first edition appeared in 1922 and the second in 1934. This edition is originally published by Edward Arnold and Co., London, and the British price is 30 shillings.

HIMMEL UND WELTALL, *Oswald Thomas*, 4th edition, 1951, *Paul Neff Verlag*, Gumpendorferstrasse 5, Vienna 6, Austria. 320 pages. DM 14.

Dr. Thomas' popular account of astronomy, which was first written in 1928, here appears in its fourth German edition. The author is a well-known teacher and popularizer of astronomy, many of whose works have appeared in English translation.

L'ASTROLOGIE, *Paul Couderc*, 1951, *Presses Universitaires de France*, 108 Blvd. Saint-Germain, Paris VIe. 127 pages, paper bound. No price given.

The author, astronomer at the Paris Observatory, discusses astronomical preliminaries, astrological doctrines, the history of astrology, and goes on to analyze, from his astronomical point of view, the position and practices of today's most prosperous pseudo-science.

ENERGY SOURCES — The Wealth of the World, *Ayres and Scarlott*, 1952, McGraw-Hill. 344 pages. $5.00.

An analysis of our energy sources, past, present, and future, and discussions of oil, coal, hydroelectricity, solar and nuclear energy, wind and tide power, are included in this book, which is written in a way to be of value to anyone with an interest in science and technology.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

TELEPHOTOGRAPHY FOR AMATEURS

INTEREST is being manifested in "eyepiece" photography, a diversion of a great many amateur astronomers owning telescopes that are otherwise idle by day. The telescope objective (mirror or lens), eyepiece, and camera lens combine in making a powerful telephoto instrument capable of producing splendidly detailed large-scale photographs of distant objects, terrestrial or celestial. The principles involved apply to the photography at night of the moon, planets, and other objects where considerable magnification is required to obtain a satisfactory image.

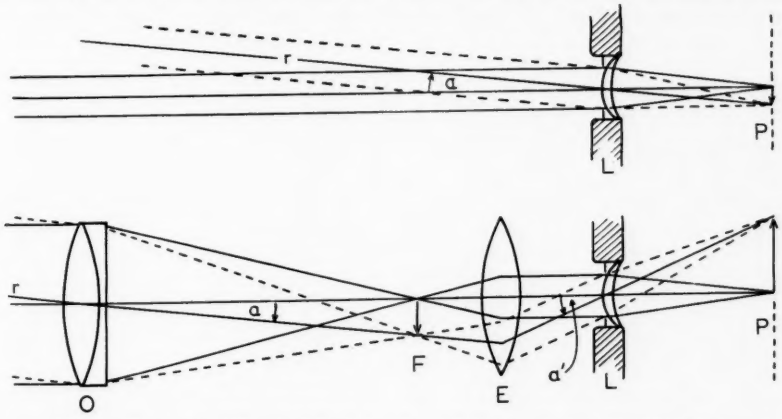
The comparative recorded image sizes of a distant object photographed directly with the camera, and photographed when the camera is placed back of the eyepiece of a telescope, are shown in the accompanying diagram. The unaided camera, with its lens **L**, and film or plate **P**, is indicated in the upper section. Since the object is assumed to be quite distant, the lens is focused for infinity. The camera is held with its optical axis aimed at the center point of the distant subject. An image of this point is recorded on the center of the film. A principal ray **r** from a boundary point of the subject passes undeviated through the center of the lens, making angle **a** with the optical axis, and ending up on the sensitized film. Parallel rays (dashed) from the same point, passing through the peripheral zone of the lens, are reunited with the principal ray on the film, where an image of the boundary point is formed. The arrow length indicates half the width of the subject image.

In the lower section, the same camera is used to photograph the same subject through the eyepiece of a telescope. In just the same way as the image in the upper diagram was formed by the camera lens, the telescope objective **O** forms a primary image in its focal plane **F**. The only difference is one of image size, this being proportional to the focal lengths of the lenses. If our diagrams illustrate an actual case, the image size has been doubled at **F**. For visual examination, an eyepiece **E** is used to magnify the image. If the eye is a normal one, so that the eyepiece is fixed with the image at its focus, rays from each subject point will emerge parallel from the eyepiece.

Now, let the eye be removed from the eyepiece, and the camera (which is a mechanical eye) be substituted in its place. As in the first instance, we are working with parallel light, and the camera must be focused for infinity. The subject image is then formed on the film **P**, but the image in this case is of greater size than in the upper diagram. The enlargement ratio is the same as the ratio of angles **a′**/**a**, and is equal to the magnification of the visually used telescope. (The reinversion of the image is incidental and immaterial.)

The eyepiece-camera distance is important in the matter of picture coverage. As only those rays creating the visual image pass through the exit pupil of the telescope, it is evident that the photographic field must be the same as the real field of the telescope. And the apparent field of the camera lens becomes the same as the apparent field of the eyepiece used. Ideally, the camera should be held so that its lens stop is in the plane of the exit pupil, and as the exit pupil diameter is the limiting effective aperture for the camera lens, the latter may in that case be stopped down to the exit pupil size. Usually, however, the exit pupil distance is too short to allow the camera to be brought this close to the eyepiece, so the stop will have to be opened up in order to contain the rapidly diverging pencils of parallel rays. To avoid possible curtailment of the picture size by the camera stop, the safest course is to open the latter to its limit.

We come now to the question of exposure time. Explanation is perhaps best done with a hypothetical case. Suppose a 1-inch eyepiece is used in a 6-inch telescope of 50 inches focal length, giving a magnification of 50 diameters. As the exit pupil diameter is equal to the lens or mirror aperture divided by the magnification, the effective diaphragm opening for the camera is 0.12 inch. Assuming a camera lens focal length of about 2-2/3 inches, the effective opening (2.66/0.12) is the same as would be obtained in stop-



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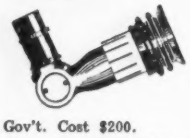

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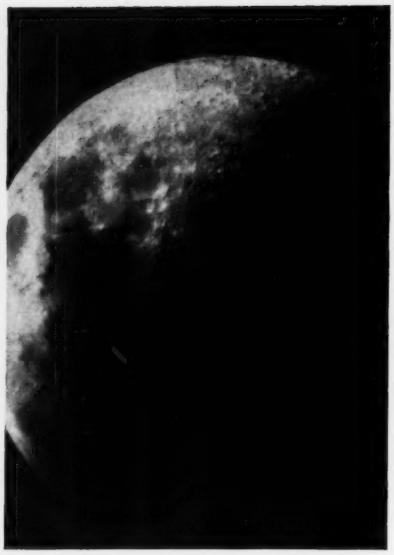

A telephotograph of the moon by James Heinemann, of the Junior Astronomy Club, New York. It was taken through a 1-inch eyepiece on a 6-inch f/8 reflector, and an f/2.9 35-mm. lens, Kodak Super-XX film, 1/10-second exposure.

ping the lens down to f/22. It must now be determined what exposure time should be used in photographing the distant subject at f/22. The brightness of the actual subject only must be considered — no sky light or other surrounding illumination. Let us assume for a particular emulsion the proper ordinary exposure time would be about 1/10 second.

With the camera placed back of the eyepiece, our imaginary combination is made the equivalent of a 6-inch f/22 camera, with image sizes in proportion. Compared to conditions in the unaided camera, we get an image enlargement of 50 diameters, spread over 50^2 or 2,500 times the area. In some way then, the illumination must be proportionately increased. This is taken care of by the light grasp of the 6-inch telescope objective, the area of which is 2,500 times that of the exit pupil or equivalent f/number opening of the camera. In every instance, whatever the image amplification, identical proportions are maintained. Theoretically then, in both our cases equal image areas are equally bright, and if this is found to be practically true, 1/10 second should be the exposure time in taking the picture through the eyepiece.

But the light losses in the telescope cannot be neglected. In a new reflector, some 40 per cent is not too much to deduct for reflection loses suffered at two mirror and four eyepiece lens surfaces. And in most cases, where the luster of fresh aluminum coatings has been dimmed, the losses will run considerably higher. It appears safe to say, therefore, that the theoretical exposure time should be doubled. In our hypothetical case, the picture would be taken at 1/5 of a second.

What actually takes place in the whole setup is that the eyepiece and camera lens together act as a projection unit, and project the primary image **F** onto **P**. The

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amplification is the result of a proportionate variance in the focal distances of **P** and **F**. The unit is comparable to the erecting system of a terrestrial telescope, but instead of the amplified secondary image being viewed with an eyepiece, it is received on the photographic film **P**. From this viewpoint, possibilities of improved picture-taking techniques at once suggest themselves, and merit investigation.

To summarize the method of the diagram: Determine for each of your eyepieces the equivalent focal ratio for the telephoto combination. An approximation (but not a careless one) of the camera lens focal length will suffice for the calculations. Focus the eyepiece carefully for visual use. If you require glasses to accommodate for normal reading distance, wear them in adjusting the focus.*

Next, focus the camera lens for infinity, open it to its fullest aperture, and bring it as close to the eyepiece as possible without touching. In this way a light shield will not be needed. Because of the relatively long exposure times, seldom less than 1/10 second except under a brilliant summer sun, the camera should be mounted on a tripod. For terrestrial subjects, turn the camera so that the film is suitably oriented with the shape of the subject as it appears in the eyepiece.

The exposure time will vary as the square of the eyepiece power, an eyepiece of ½-inch focal length requiring four times as long an exposure as a 1-inch. Lowest powers give the greatest detail. Any type of eyepiece may be used, although the achromatic kinds give better results; orthoscopics are best of all for the purpose.

ALLYN J. THOMPSON
1628 Mayflower Ave.
New York 61, N.Y.

A method of attaching a camera to a reflector, by Richard Willey.

*A more accurate method of adjusting for parallel light (infinity focus) is to obtain a small telescope with a magnification of 4x to 6x, and to adjust it for focus on a star or planet or on the moon. Then place the objective of this telescope in the exit pupil of the main instrument and, observing through the auxiliary, adjust the focus of the main telescope until a clear image is obtained. If the auxiliary has a reticle, the adjustment may be made better by parallax (moving the eye from side to side, and changing the focus until there is no apparent movement between image and reticle); be sure the reticle is correctly adjusted for infinity focus. This method of adjustment minimizes the effects due to the observer's vision — which effects may be considerable, even with 20/20 vision. — ED.

TERMINOLOGY TALKS

(Continued from page 88)

They seemed in no special hurry — truly quite lazy meteors.

Groups continued to come at short intervals, all along the same route. A student who used opera glasses estimated there were at least 10 groups and each contained from 20 to 40 meteors. A few minutes after the red leader had appeared, a single clear, white rearguard without a tail sailed leisurely across the same sky path — and the show abruptly ended. Several remarked that in the various groups the individuals kept in perfect formation in parallel paths, remaining in exactly the same relation to each other as they glided calmly across the heavens.

As to the number of the meteors seen, there was a wide divergence of opinion from widely separated observers. "There were thousands of them." "About 200 in all." "Four distinct lots." "There were only 8, all traveling singly excepting the last 2." "Total number, 15 or 20." "There were 4 groups consisting of 6, 4, 3, and 1." "More than a dozen." "Only 15 in all, one at a time." From the S.S. *Newlands* off eastern Brazil, the deck officer said there were 50 meteors and six minutes were required for them to pass.

Those at a considerable distance from the ground path (the trace on the earth directly beneath the actual sky path) reported the meteors seemed to be traveling practically parallel to the horizon.

From many places not far from the ground path, audible effects were noticeable. I find no accounts of loud gutteral sounds such as sometimes follow the flights of huge fireballs.

(To be continued)

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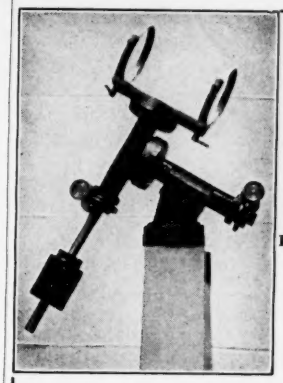

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

VISUAL OBSERVING PROGRAMS FOR AMATEURS — XXIII

Eclipsing Variable Stars

EVERY few years the headquarters of the American Association of Variable Star Observers receives requests for determinations of the times of minima of Algol from professional astronomers who are studying that star, indicating continuing value in observing it visually. There are other eclipsing variables upon which professional astronomers would like more visual observations, although it is true that most of the detailed researches are based on work done with photoelectric photometers. In their book, **The Story of Variable Stars,** page 197, Campbell and Jacchia say:

"The routine observation of eclipsing variables during eclipse stages can, however, be productive of valuable results, if designed to determine accurately the times of minimum. This sort of work pertains more particularly to those Algol stars which vary through large amplitudes, and for which the astronomer needs to be kept well informed as to the time of the eclipse for his studies of apsidal motions or anomalous irregularities in period."

A new program. At present there is a plan to try to interest amateurs in doing more work on eclipsing variables. How well this effort will succeed will depend upon how much work we, as amateurs, actually do. If you are interested, you should get in touch with Mrs. Margaret W. Mayall, Recorder, AAVSO, Harvard Observatory, Cambridge 38, Mass., or Dr. Joseph Ashbrook, Yale University Observatory, Prospect and Canner Sts., New Haven 11, Conn.

It is much more difficult to observe eclipsing stars usefully than it is long-period variables, because isolated observations of the former are valueless. The observer must, in general, continue his estimates over several hours, to cover something of both the descending and the ascending branches of the light curve. Moreover, his observations must be more than ordinarily accurate, and they should be free from errors produced either by personal bias or by changes in observing conditions during the period covered by the series of observations.

Until both the observers and the AAVSO headquarters have had some experience with this newly proposed program, it is suggested that work should be started on Algol, RZ Cassiopeiae, and SZ Herculis, which are included in the accompanying list of representative eclipsing systems. If the work flourishes, the program might later include the other stars.

SOME ECLIPSING BINARIES

Star	*Magnitude*		*Period*	*Ecl.*
	Max.	*Min.*	*days*	*hours*
Algol (β Persei)	2.3	3.5	2.87	9
Delta Librae	5.0	6.1	2.33	13
RZ Cassiopeiae	6.0	7.7	1.20	5
U Cephei	7.0	9.0	2.49	10
TX Ursae Majoris	7.0	9.1	3.06	11
RW Tauri	8.0	12.3	2.77	9
XX Cephei	8.5	9.5	2.34	8
SZ Herculis	9.5	11.3	0.82	4
XZ Andromedae	9.5	11.7	1.36	6
UW Bootis	10.5	11.5	1.01	5
RT Persei	10.5	11.9	0.85	4
Z Draconis	10.5	12.7	1.36	6

The total duration of the eclipse is in hours. The periods are generally subject to slight changes. XZ Andromedae is easily found and easily observed. RW Tauri has a wide range, with a very rapid fall and rise in brightness. All but two stars are like Algol, in spending no time at minimum — they begin to brighten as soon as they have reached minimum; U Cephei has a flat-bottomed two-hour minimum; RW Tauri has a one-hour minimum.

The observer will need an ephemeris of the star in which he is interested, so he may know in advance approximately when a minimum will be observable. Such predictions for Algol are given in **Sky and Telescope** and in the **Observer's Handbook** of the Royal Astronomical Society of Canada. Information for the other stars should be requested by qualified observers from Mrs. Mayall or Dr. Ashbrook. Also needed are the position of the star and a sufficiently good chart to locate the variable star and comparison stars of the observer's own choosing in the area. The locations of these comparison stars should be shown on a tracing of the chart, which should be submitted with the observations when they are sent in later.

Observing methods. It is suggested that brightness estimates be made by the Pickering interpolation method. Choose two suitable comparison stars (with the hope that they will not turn out later to be variable stars themselves); one should be brighter than the eclipsing variable, the other fainter. Call the brighter **a** and

VARIABLE STAR MAXIMA

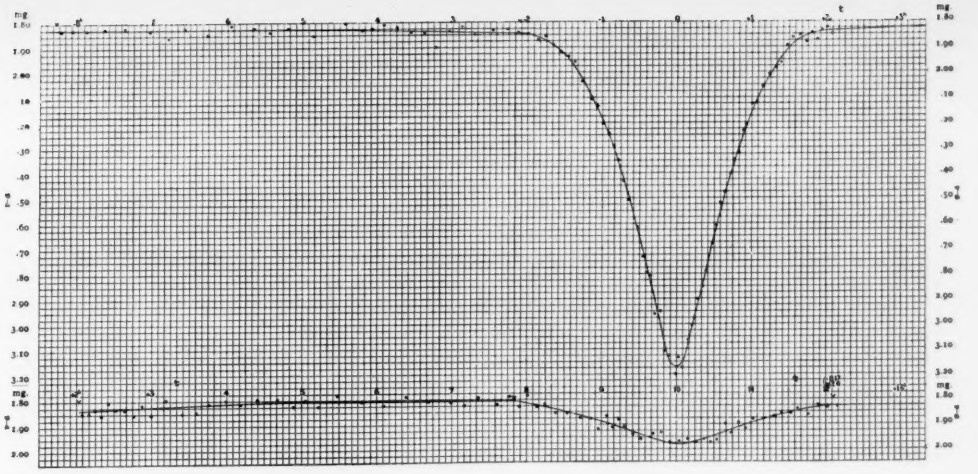
February 5, S Carinae, 5.7, 100661; 12, W Andromedae, 7.5, 021143a; 17, R Geminorum, 7.1, 070122a; 29, T Aquarii, 7.9, 204405. March 1, V Ophiuchi, 7.5, 162112; 2, R Canum Venaticorum, 7.7, 134440; 2, T Hydrae, 7.7, 085008.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

MINIMA OF ALGOL

February 3, 12:59; 6, 9:49; 9, 6:38; 12, 3:27; 15, 0:17; 17, 21:06; 20, 17:55; 23, 14:45; 26, 11:34; 29, 8:23.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See Sky and Telescope, Vol. VII, page 260, August, 1948, for further explanation.



The mean light curve of the eclipsing binary RT Persei, by R. S. Dugan, showing both primary minimum (upper part of curve) and secondary minimum (lower part). The primary eclipse is annular, but limb darkening causes it to appear partial. There are ellipticity and reflection effects involved also. One star is about seven times as bright as the other. Princeton University Observatory chart.

the fainter **b**. Make and report your observations to the recorder of the AAVSO in this form:

Nov. 4, 1951, 9:51 p.m. EST, **a**:6:RZ Cass:4:**b**

This means that RZ Cassiopeiae appeared 6/10 (60 per cent) of the way down (fainter) from **a** toward **b**. Two other stars, **c** and **d**, can be used for an independent observation, but often one is hard put to find even two proper comparison stars in the same field as the variable. Furthermore, as the eclipse deepens and the variable becomes fainter, other comparison stars may have to be pressed into service.

Record the times of observations to the nearest minute. For slowly varying stars, estimates can be made at intervals of 15 to 20 minutes or more, to avoid bias. Begin about 1½ hours before the time of predicted minimum and run for as long afterward, because, in general, what is wanted is a complete light curve around the time of minimum. (Our later discussion of Algol will show that this is not always necessary, nor may it be the most accurate method of determining the exact time of minimum for some stars.)

The actual observation can be made by glancing back and forth between the eclipsing variable and the comparison stars, looking attentively at each in turn. Throwing the images out of focus and comparing the brightnesses of the out-of-focus disks is sometimes helpful, especially if one is using binoculars. Other observers prefer to look about midway between the two stars which are being compared. If this is done, be sure to tilt your head so that the two stars appear on a line parallel to that between your eyes.

Great pains should be taken not to remember previous observations, and the observer should try to avoid making up his mind as to whether the star is increasing or decreasing in brightness. If there is time between observations to devote to work on other variable stars, it may serve to free your mind, but I usually find that I have to concentrate on one program at a time to do a good job.

If you have a short-wave radio receiver with an outdoor aerial, it may be possible to get your time from WWV as described in the article on occultations last month. However, I can't hear WWV on my radio, so for variable star work I set my watch by U. S. Naval Observatory time at a local jeweler's the afternoon before observing and check it again the next morning.

As estimating a variable's brightness in the manner suggested above may take from 30 to 60 seconds for each determination, I endeavor to allow for this when jotting down the time of observation. For the lone-wolf observer, timing to about 15 seconds is as close as seems possible or useful in this kind of work.

The predictions for the times of Algol's minima mentioned above are corrected for the equation of light, that is, they are geocentric and not heliocentric. At the center of the sun, the observed times of minima would occur at substantially equal intervals, but the times shown in the ephemerides are about 7½ minutes early in the first week of November (at the time the earth is nearest in its orbit to Algol) and about 7½ minutes late in early May (when the earth is farthest in its orbit from Algol). For other stars, these corrections from heliocentric to geocentric times will be different, depending upon the star's position with regard to the plane of the earth's orbit and the time of year when the earth is nearest the star in question (when the star is at opposition to the sun). The main point to bear in mind is that if one is observing at other times than when the star is near opposition and if one makes two series of observations, say several weeks apart, some correction for the equation of light as it affects the two sets of observations may be necessary. For a more complete discussion of this matter, see Roy A. Seely's article in **Sky and Telescope,** August, 1948, pages 260 and 261.

The above outlines the plan for the proposed new program of observations on eclipsing variable stars. Presumably each star will present its own special observational problems, and to overcome these the observer may need both experience with that star and some ingenuity. The amount of experimentation required is indicated by next month's description of the method for determining the time of a minimum of Algol, which Mr. Seely and I worked out during the years 1943 to 1947, with the advice of Dr. Harlow Shapley and Leon Campbell. Remember, however, that this method may have to be altered for other eclipsing variables.

DAVID W. ROSEBRUGH
79 Waterville St.
Waterbury 10, Conn.

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

Vesta, 4, 6.6. Feb. 8, 11:08.1 +15-09; 18, 11:00.9 +16-35; 28, 10:51.9 +18-00. March 9, 10:42.4 +19-13; 19, 10:33.7 +20-06; 29, 10:27.0 +20-35.

Diana, 78, 9.5. Feb. 8, 11:00.1 +6-57; 18, 10:51.3 +6-49; 28, 10:41.2 +6-48. March 9, 10:31.2 +6-48; 19, 10:22.7 +6-45; 29, 10:17.0 +6-35.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1952.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

February 18-19 **Tau Scorpii** 2.9, 16:32.9 −28-07.1, 24, Im: **G** 13:29.2 −1.5 +0.4 92; **H** 13:15.7 −1.6 −0.1 117. Em: **I** 14:30.7 −1.5 0.0 285.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +31°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

SATURN'S SATELLITES

SATURN, besides its unique ring system, has a retinue of satellites worthy of the telescopist's attention. Seven of the nine are visible in moderate-sized instruments. The phenomena for these are given below for the next two months, and the apparent orbits are shown in the accompanying diagram.

Satellite	Synodic Period		Magnitude	Mean Distance
	days	hours		
Mimas	0	22.6	12.1	27″
Enceladus	1	8.9	11.6	34″
Tethys	1	21.3	10.5	43″
Dione	2	17.7	10.7	55″
Rhea	4	12.5	10.0	76″
Titan	15	23.3	8.3	177″
Hyperion	21	7.6	13.0	214″
Iapetus	79	22.1	10.1-11.9	515″
Phoebe	523	15.6	14.5	1870″

For the first five satellites listed below the times given are for eastern elongation only, every eighth one for Mimas, Enceladus, and Tethys, and every fourth one for Dione and Rhea. For Titan and Iapetus the configurations around the orbit are given: **E**, eastern elongation; **I**, inferior conjunction; **W**, western elongation, and **S**, superior conjunction. The month is given, then the day and the hour in tenths, Universal time. For instance, for Titan the first event is an eastern elongation on February 1st at $0^h.4$ UT. The brightness of Iapetus is variable; compare it with the other satellites. This information is selected from the **American Ephemeris.**

Mimas. February: 1, 21.1; 9, 10.0; 16, 22.9; 24, 11.8. March: 3, 0.7; 10, 13.6; 18, 2.5; 25, 15.5. April: 2, 4.4.

Enceladus. February: 2, 0.5; 12, 23.6; 23, 22.6. March: 5, 21.6; 16, 20.7; 27, 19.7.

Tethys. February: 2, 10.4; 17, 12.8. March: 3, 15.2; 18, 17.5. April: 2, 19.8.

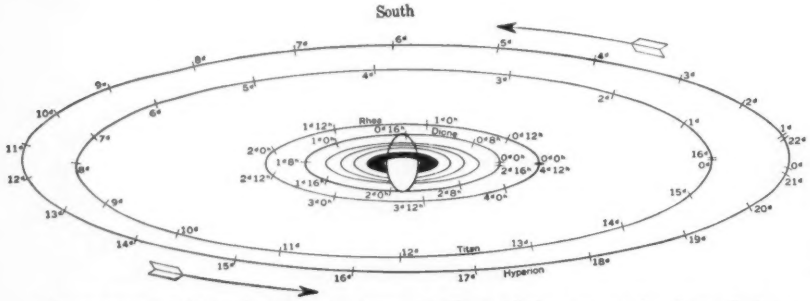
Dione. February: 2, 13.1; 13, 11.7; 24, 10.4. March: 6, 9.0; 17, 7.6; 28, 6.2.

Rhea. February: 3, 0.7; 21, 2.2. March: 10, 3.6; 28, 4.9.

Titan. February: **E**, 1, 0.4; **I**, 4, 19.3; **W**, 8, 20.6; **S**, 13, 0.8; **E**, 16, 22.7; **I**, 20, 17.5; **W**, 24, 18.6; **S**, 28, 22.8. March: **E**, 3, 20.6; **I**, 7, 15.3; **W**, 11, 16.3; **S**, 15, 20.5; **E**, 19, 18.3; **I**, 23, 13.0; **W**, 27, 13.8; **S**, 31, 18.0.

Iapetus. February: **I**, 4, 22.1; **W**, 24, 0.7. March: **S**, 15, 9.5. April: **E**, 4, 11.8.

E. O.



The apparent orbits of the seven inner satellites of Saturn, at the date of the planet's opposition, April 1, 1952, as seen in an inverting telescope (south at the top), and elongated in the ratio of two to one in the direction of their minor axes. Diagram from the "American Ephemeris."

A PARTIAL LUNAR ECLIPSE

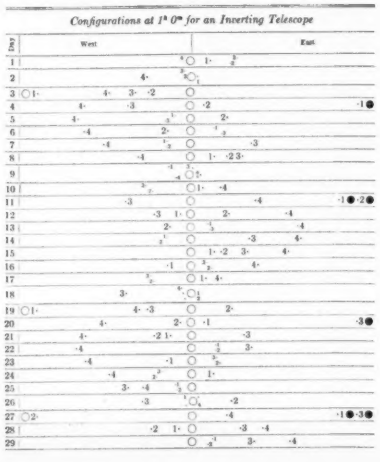
There will be a partial eclipse of the moon the night of February 10-11, visible from the United States except the Far West, where sunset occurs just as the moon is leaving the umbra. At maximum obscuration, only 8.8 per cent of the lunar diameter will be in the umbra of the earth's shadow. The shadow will fall on the southern limb at a place 173° west of the north point and will leave at position angle 138° west of north; no prominent lunar features are visible in this vicinity.

There will be good opportunity for eastern observers to watch the penumbral phases, trying to ascertain how long before and after the umbral phases the darkening of the penumbra may be detected (see **Sky and Telescope,** September, 1951, page 270). The circumstances of the eclipse, all for evening hours of Sunday, February 10th, are:

	EST	CST
	p.m.	p.m.
Moon enters penumbra	5:06.2	4:06.2
Moon enters umbra	7:03.3	6:03.3
Middle of eclipse	7:39.3	6:39.3
Moon leaves umbra	8:15.3	7:15.3
Moon leaves penumbra	10:12.4	9:12.4

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.



DEEP-SKY WONDERS

IN MAY last year, this column listed three galaxies in Leo Minor, NGC 3414, magnitude 12.2; NGC 3504, 11.7, and NGC 3486, 11.4. Observers were asked to report on the **visibility** of these objects under various apertures and powers. The several amateurs who collaborated merely add evidence that the problem of nebular visibility is not a simple one. We are especially indebted to Capt. William Galbraith, Lemon Grove, Calif.; James Corn, Phoenix, Ariz.; and to Fred Grabenhorst, O'Fallon, Mo.

The observers all agree that it requires more than three inches to see 11th-magnitude objects. With a 12½-inch instrument, Corn tried reduction masks until the visibility was nil. But, on the effects of powers they differ. With a 5-inch telescope, Galbraith met "increasing difficulty" as he raised his magnification, whereas Corn found 3414 and 3504 as easy at 400x as at 80x. But Corn says that 3486 seemed to fade off with increasing powers; and all three were invisible at 1,000x. Grabenhorst was unable to see any of these galaxies with a 3-inch telescope.

The Arizona observer suggests that 3486 has "luminosity per unit area evidently much lower than the other two." Galbraith, a variable star observer, estimates the magnitudes differently from the catalogues: 3414, 12.0; 3504, 12.0; 3486, 12.3.

From these and other reports it seems likely that nebular brightness holds fairly steady as magnification increases until a certain point, after which it falls off very fast. My own experience has been about halfway between those of Corn and Galbraith. The optical system may have considerable effect. It might be interesting to compare Newtonian and Cassegrainian arrangements. See the October, 1951, column for similar material on the visibility of NGC 6822.

WALTER SCOTT HOUSTON

LUNAR CRATER DIAMETERS

D. W. G. Arthur, librarian of the lunar section of the British Astronomical Association, has published Part I of a three-part catalogue, **The Diameters of Lunar Craters.** It contains 1,000 objects, from Abenezra through Gambart F, in 20 mimeographed pages.

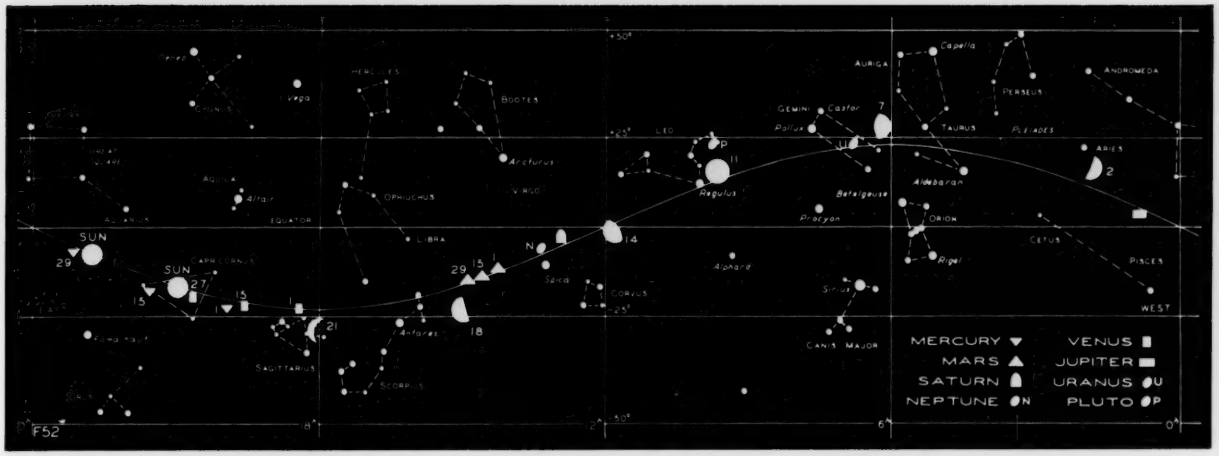
The diameters were based on observations on all existing lunar photographs. They are given in units of 1/1,000 of the moon's radius, and may be converted to miles by a factor of 1.08.

No price for the catalogue is given. Serious students of the moon may communicate directly with Mr. Arthur, at 35 Vastern Road, Reading, Berks, England.

MOON'S PHASES AND DISTANCE

First quarter	February	2, 20:01
Full moon	February	11, 0:28
Last quarter	February	18, 18:01
New moon	February	25, 9:16
First quarter	March	3, 13:43

	February	Distance	Diameter
Apogee	8, 9h	252,300 mi.	29′ 25″
Perigee	23, 22h	223,900 mi.	33′ 10″
	March		
Apogee	6, 23h	251,800 mi.	29′ 29″



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun. The only total eclipse of the year takes place on February 25th, invisible from Western Hemisphere continents. The path crosses central Africa, Arabia, and ends in Siberia, with most of three continents, including Europe, viewing the partial phases. The greatest duration of totality will be three minutes 9½ seconds, in the Anglo-Egyptian Sudan near Khartoum. See the December, 1951, issue, page 37, for a map and information on expeditions.

Moon. The earth's satellite will be in partial eclipse on February 10-11 during evening hours as seen from the United States. See the note in this department for further details.

Mercury will be invisible all month, passing superior conjunction with the sun on February 22nd.

Venus rises before or during dawn as a brilliant object of magnitude −3.4. It will be of little interest until next winter, spending most of the year not too distant from the sun in the sky. In a telescope, Venus presents a disk 13″ in diameter, 84 per cent illuminated on February 15th.

Mars increases in brightness from magnitude +0.8 to +0.2 during February. It rises before midnight, except for the first few days of the month, and is moving in direct motion in western Libra.

Jupiter sets four hours after the sun in mid-February. Just outshining Sirius at −1.7 magnitude, the planet is the brightest object in the evening sky. On the evening of February 26-27, only one of the four bright satellites will be visible, Callisto.

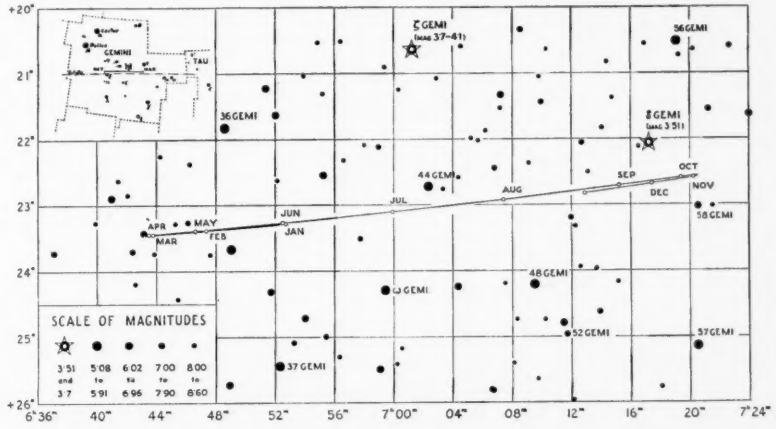
Saturn appears above the eastern horizon about 9:30 p.m. local time, on the 15th. Moving retrograde in central Virgo, the planet is of the 1st magnitude. The ring system is inclined 9°.4 to the line of sight in mid-February. Phenomena of the satellites are discussed on page 100.

Uranus is above the horizon until dawn, visible with the aid of opera glasses. See the chart of its path on this page.

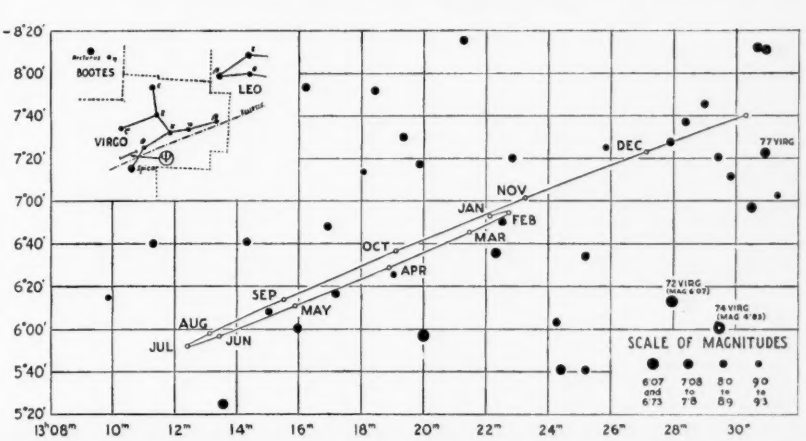
Neptune, in retrograde motion preceding opposition, passes Spica for the second time this year. On February 4th, the planet will be 4° 1′ north of the star, rising about 11 p.m. at that time. Its path for the year is shown below.

Pluto comes to opposition on February 10th, and is of the 15th magnitude. It is approximately 35′ south of Epsilon Leonis at 9h 43m 29s, +23° 25′.2 (1950 co-ordinates) at opposition. A telescope with a minimum of 12 inches aperture and a detailed chart of the region are required for identification of this faint object.

E. O.



The path of Uranus among the stars in Gemini during 1952 is shown above; that for Neptune among the stars in Virgo, below. In each case the field is inverted, with south at the top, as seen in an astronomical inverting telescope. The scale of the charts is not the same. From the 1952 "Handbook" of the British Astronomical Association.

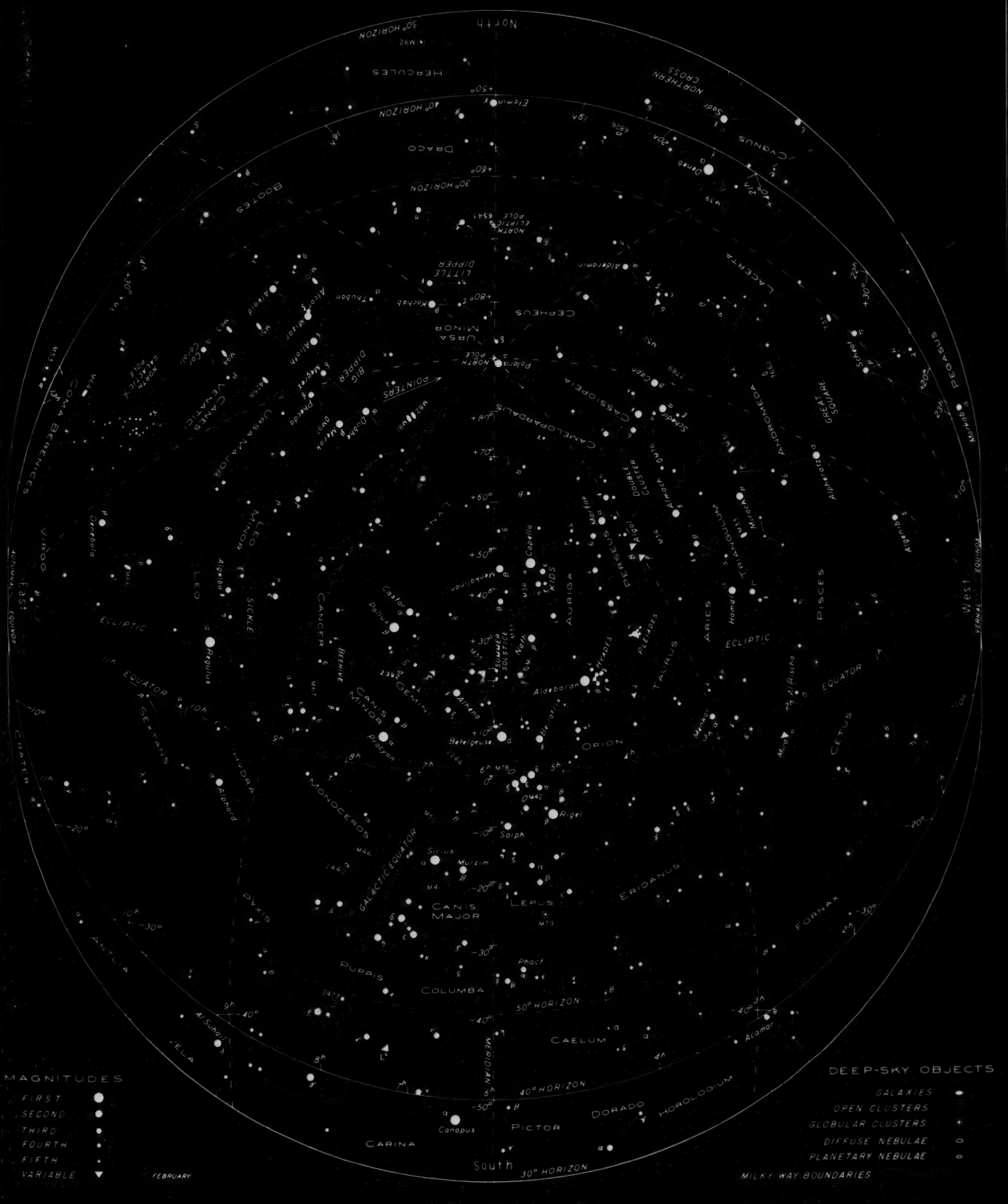


The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of May, respectively.

SOUTHERN STARS

TWELVE of the south circumpolar constellations (see page 259, August, 1951) are now known definitely to have been delineated and named by Pieter Dircksz Keijser, during a sojourn at Madagascar late in 1595 and early in 1596. Noted for his knowledge of mathematics and astronomy, having been instructed by Peter Plancius, Keijser served as chief pilot and head of the steersmen of the **Hollandia**, of the Dutch East India Company. He made his observations of the southern stars "sitting in the crow's nest," and although he died on September 13, 1596, his star positions were turned over to his teacher Plancius. They found their way into the hands of Jodocus Hondius, whose celestial globe of 1600 shows Keijser's configurations.

The 12 constellations are: Phoenix, Hydrus, Dorado, Musca, Volans, Chamaeleon, Triangulum Australe, Apus, Pavo, Indus, Grus, and Tucana, according to an article by Dr. J. W. Stein, S. J., Vatican Observatory, which is excerpted by Dr. Helen S. Hogg in her department "Out of Old Books," in the September-October, 1951, issue of the **Journal** of the Royal Astronomical Society of Canada. To Father Stein goes credit for establishing Keijser as originator of these groups.



STARS FOR FEBRUARY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of February, respectively; also, at 7 p.m. and 6 p.m. on March 7th and 23rd. For other times, add or subtract ½ hour per week. When facing north, hold "North" at the bottom; turn the chart correspondingly for other directions. The projection (stereographic) shows celestial co-ordinates as circles.